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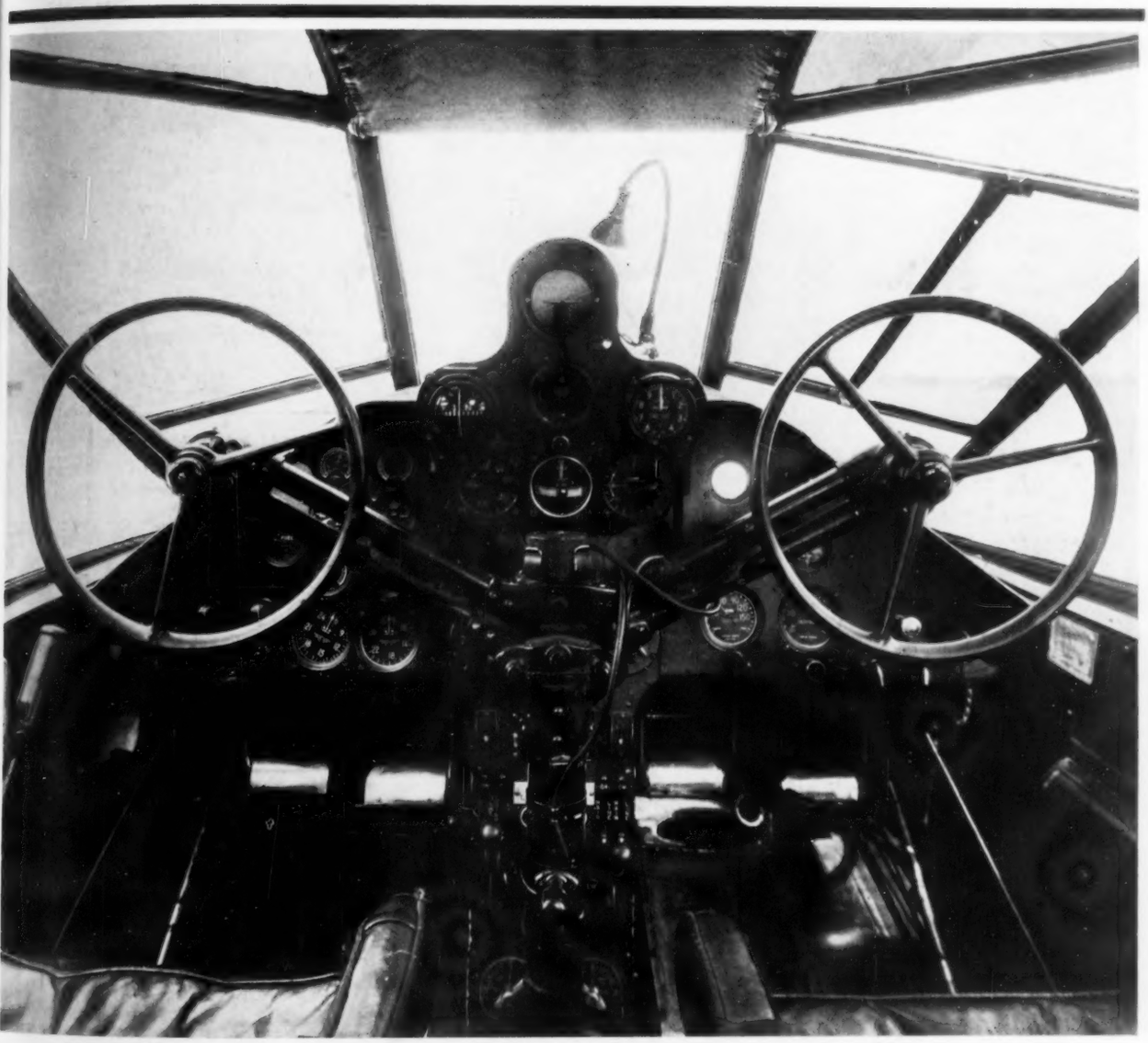
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

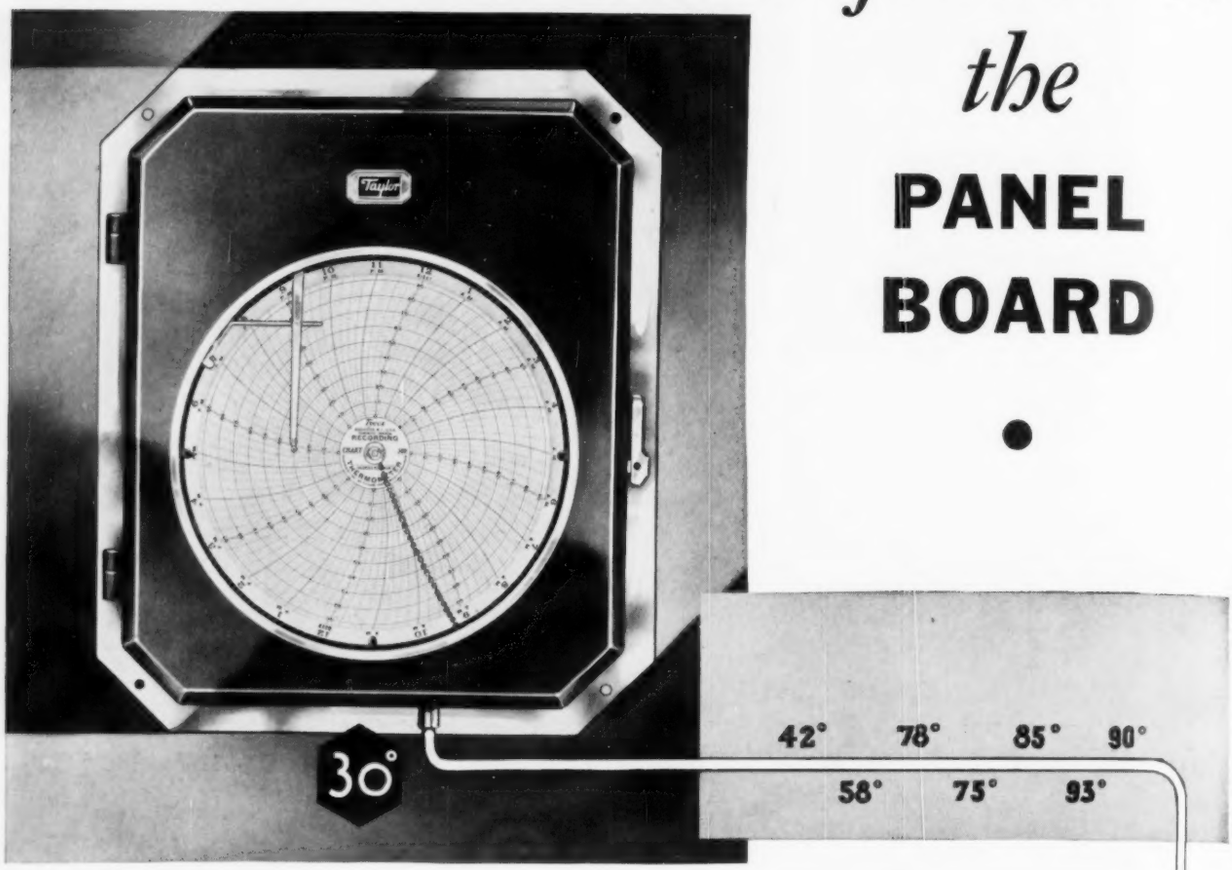
VOLUME 6 FEBRUARY, 1933 NUMBER 2



INSTRUMENTS FOR "BLIND" FLYING INSTALLED ON EASTERN AIR TRANSPORT PLANES (*Courtesy Howard C. Stark*)

TEMPERATURE and HUMIDITY MEASUREMENT and CONTROL

NEW RECORDER *flashes on the* PANEL BOARD



Taylor brings new beauty to the power plant and sets new standards of accuracy for mercury-actuated recorders with remarkable Accuratus Tubing

NEW beauty has entered the power house. The new Taylor Rectangular Recorder, with its modern-art case, sets a distinctive style in case design. Practical-minded engineers are enthusiastic over its clean-cut lines . . . its proportions and its striking appearance.

The case is in lustrous black enamel with a relieving spot of silver in the Taylor name-plate. There are two types of cases—one for surface and one for flush mounting.

Inside, the construction is according to highest Taylor standards. If anything, this new recorder is more rugged than previous types. The spring is of an alloy made to special Taylor specifications. It is thoroughly seasoned and heat-treated to eliminate inaccuracies. Joints are all welded.

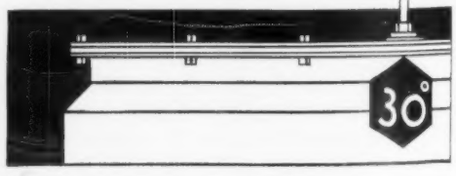
Mercury-actuated recorders are recommended as most efficient for the power plant. Gas- and vapor-actuated systems, however, can be supplied. Mercury-actuated instruments have an exclusive feature in the new Taylor Accuratus Tubing, the most accurate temperature compensating tubing ever used.

For complete information regarding the Rectangular Power Plant Recorder and Accuratus Tubing, ask a Taylor sales engineer or write to the Taylor Instrument Companies, Rochester, N. Y.

REMARKABLE ACCURATUS TUBING

With this new tubing, Taylor mercury-actuated temperature recorders register the true bulb temperature no matter how much variation there may be between. Lengths of 100 feet or more may be used without affecting accuracy of chart records. Compensation for ambient temperatures is built into the tubing. No auxiliary devices to get out of order. Temperature compensation is permanent.

Accuracy is due to its uniform bore. This tubing is the most accurately gauged, heavy-wall, small-bore steel tubing ever made. Only .0005 of an inch tolerance is allowed.



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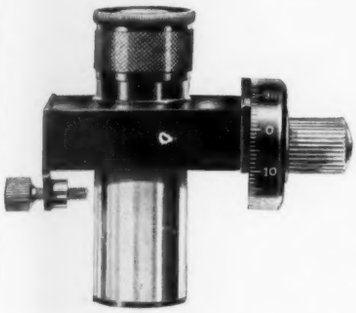
THE FILAR MICROMETER



enables the microscopist to make most accurate measurements and can be attached to any microscope. A micrometer screw acts on a slide that carries the movable wire. One revolution moves the wire 1.0 mm across the field. The adjustable drum head of this screw is divided in 100 parts, 1 part being equal to 0.01 mm. 1/10 of this interval (equal to 0.001 mm = 1u) can easily be estimated. A scale placed in the field and ruled in intervals of 0.5 mm serves for counting the revolutions of this screw. The eyepiece is of the Ramsden type with 12.5 × magnifications.

Price.....**$38.00**

STAGE MICROMETERS

(Supplied in lined leatherette cases)—These micrometers consist of slides 75 × 25 mm with scales ruled directly in the slide. No. 1861 is ruled to 0.1 and 0.01 mm. No. 1862 is ruled to 0.01 and 0.001 inches. Both have cover glasses of No. 1 thickness.

Price—No. 1861 ..... **$7.00**
Price—No. 1862 ..... **8.00**

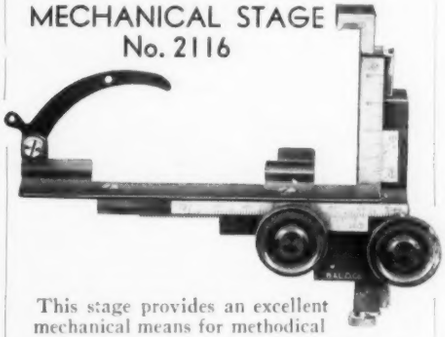
MICROMETER EYEPIECES

No. 1856 **No. 1866**

are furnished in two forms—No. 1866 with a movable scale and No. 1856 with a fixed scale, both scales measuring 5 mm. Both scales are divided into tenths of a mm with every fifth and tenth line numbered. Eye lens is adjustable for focusing magnification 7.5×.

Price—No. 1866 ..... **$16.00**
Price—No. 1856 ..... **7.25**

MECHANICAL STAGE No. 2116



This stage provides an excellent mechanical means for methodical examination of a slide from corner to corner. The clamp is extendable to fit any square stage. One closed end with clamping screw provides for instant leveling. Rack and pinion adjustments give equal speeds in both movements. Right and left scale reads 75 mm and forward and back scale 45 mm. Both scales graduated in single mm's with verniers attached reading to tenths. Accommodates any slide up to 50 mm in width.

Price **$30.00**

FOR AREA MEASUREMENTS

B&L MICROMETER DISCS

are of glass 21.3 mm in diameter, having lines ruled with a diamond. They fit inside standard eyepieces and are placed scale downward on the eyepiece diaphragms when in use so as to be in the focus of the eye lens.

1859A—Ruled to 0.5 mm squares, every second line on two adjacent sides numbered.
Price **$3.25**

1859B—Ruled in 1.0 mm squares, every line on 2 adjacent sides numbered.
Price **$3.00**

1859E—Howard Micrometer Disc, ruled in squares equal to 1/6 the diameter of the opening in eyepiece diaphragm, for mold counting.
Price **$5.25**

1859C—Whipple's eyepiece Micrometer Disc, having a large square divided into four, each of which is subdivided into 25 squares, and one of these again subdivided into 25; used for counting bacteria.
Price **$5.25**

FOR COUNTING

THE HOWARD MOLD COUNTING CHAMBER

Consists of unruled area 19 mm in diameter, 0.1 mm in depth, surrounded by a moat. Slide and cover glass surfaces are optically worked as in blood counting chambers. For best results we suggest Nos. 1121 (16 mm) and 1128 (8 mm) apochromatic objectives and Nos. 1200 (5×) and 1208 (15×) compensating eyepieces. Can be used with micrometer disc No. 1859E (see above) for mold counting.
Chamber only (in case) Price..... **$7.00**

THE RAFTER COUNTING APPARATUS

is used for counting organisms in water. It consists of a rectangular cell 50 mm × 20 mm, 1 mm deep, micrometer disc 1859B (see above) three cover glasses and one No. 15956 pipette 1 cc capacity.

Price (complete) **$12.00**

Other stock accessories or modifications of those listed above are available. Prices on request.

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INSTRUMENTS

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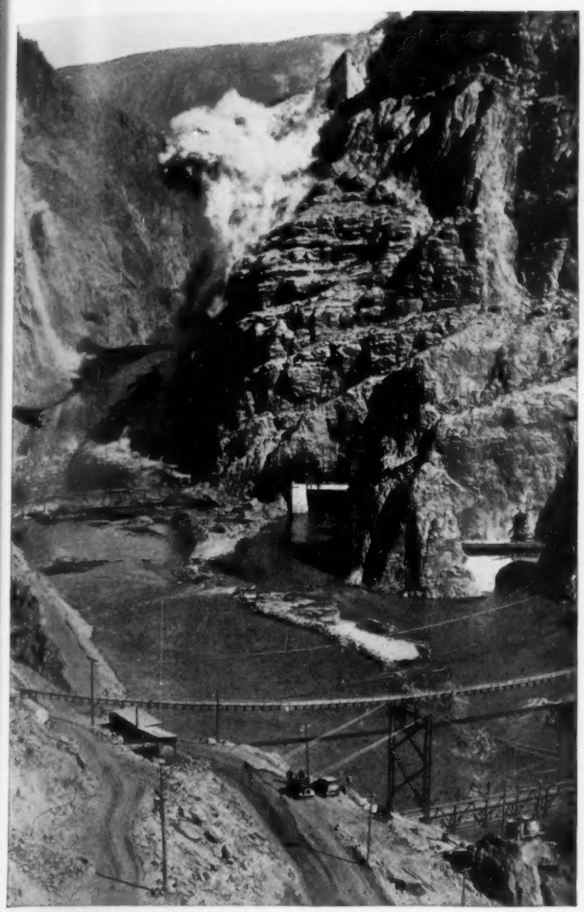
INTELLIGENT RESEARCH



Is Saving the Government Millions of Dollars in the Construction of

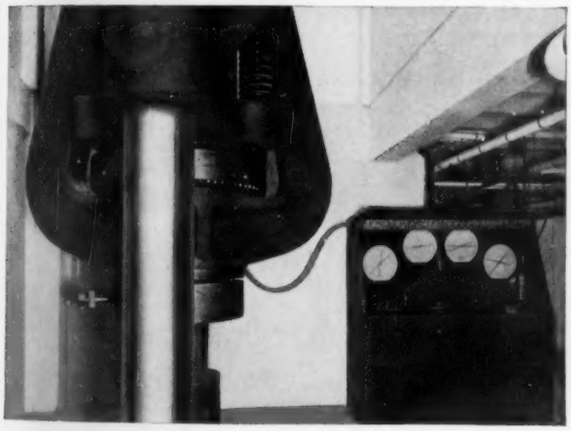
HOOVER DAM

Because this project was of such unprecedented magnitude, involving pioneering in new realms of engineering achievement—probably the most elaborate research activity ever undertaken in connection with engineering construction was necessary.

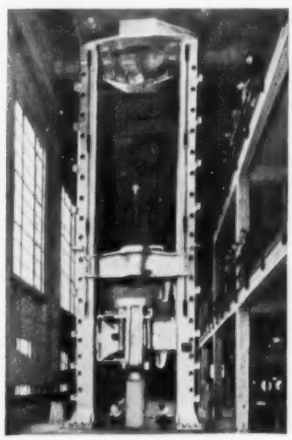
Studies of the stresses in specially constructed models and tests on specimens of materials to be used have already resulted in savings in construction costs many times that of the research work.

Among the machines and instruments employed are two Southwark-Emery hydraulic testing machines—one of which is the largest of its type in the world.

These machines are the 4,000,000 lb. universal testing machine at the University of California and the 4,000,000 lb. compression-testing machine in the Customs House in Denver. Part of the work performed on these machines has been the testing of 3 ft. diameter by 6 ft. high concrete columns. The large size of the specimens was necessitated by the fact that unusually large aggregate will be used in the concrete.



4,000,000 lb. Southwark-Emery Compression Testing Machine, installed in Custom House, Denver.



The University of California's 4,000,000 lb. Southwark-Emery Universal Testing Machine.

With the most important assemblage of experience, engineering talent and manufacturing resources ever devoted to the development of testing equipment, it is logical that Southwark machines should have been selected to assist in this great engineering work.

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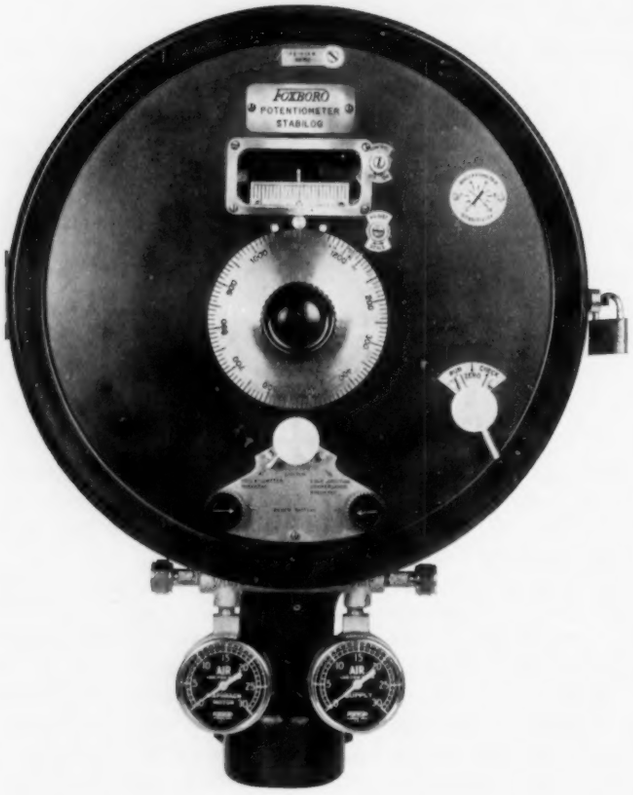
SOUTHWARK

The Potentiometer Stabilog...



Combines Two Outstanding Systems

◆Electrical temperature measurement plus air-operated control is a combination that has no equal on difficult control problems. The advantages of both of these are found in this new instrument that combines Potentiometer measurement with 100% automatic STABILOG Control.

◆The Potentiometer Stabilog was designed primarily to control the higher temperatures (800°F. or over) but it may also be used on the lower ranges where there is a possibility of over-range under starting conditions. Its electrical measuring system makes this instrument indispensable where the distance or height between the measurement point and the controller prohibits the use of the usual thermal system. The design of the instrument is such that a record of its operation may be made on a Foxboro Recording Pyrometer using the same thermocouple.

◆A complete description of the Potentiometer Stabilog should be of interest to every engineer interested in instruments or control. We will gladly send you a copy of Preliminary Description No. 191. Write for your copy today.

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EDITORIAL COMMENT

In This Issue

♦ Experience has shown that a subfloor consisting of a layer of nailing concrete poured over a structural slab of Portland cement concrete, takes "weeks" to dry enough to permit laying the wooden top floor. How many weeks in any particular case? **M. E. Dunlap,** in our leading article, tells how new instruments give the answer—correctly.

♦ **Prof. De Juhasz** concludes the chapter on Electric Indicators, in his valuable treatise on **Engine Indicators,** with original discussions of some modern instruments worth knowing.

♦ And in his chapter on positive meters, **M. F. Béhar** includes this month descriptions of liquid displacement meters which have never appeared in print up to now. Some of the drawings, in fact, were made after January 31 of this year.

♦ Thirty brief articles constitute this month's **New Instruments Section,** but four announce each two new devices, so that there are thirty-four instruments for the reader to look up. Certainly, each reader will find at least one device answering an immediate problem.

♦ Did you know that fifty-eight experienced abstractors compile this magazine's **Current Literature Review** from nearly seven hundred technical periodicals published in all continents of this globe?

♦ The **Manufacturers' Literature** always contains mentions of booklets worth writing for. Fill out the coupon.

◆ ◆ ◆

The Front Cover

♦ Howard C. Stark, the famous bad-weather pilot whose book on "Instrument Flying" has done much to advance this art, designed the blind flight panel seen between the two "sticks." This ingenious panel mounts *two* complete sets of instruments. If the pilot prefers flying by the Sperry system (using ailerons first to bank the plane) he watches the upper instruments; if he prefers the Pioneer system (using rudder first, then ailerons) he is guided by the instruments which form the bottom row of the panel.

Curtiss Condor being flown with automatic pilot.

"Industry's Third Horizon?"

UNDER the above heading there appeared in the January *Industrial Bulletin* of Arthur D. Little, Inc., an article which constitutes one of the most sincere tributes ever paid to industrial process instruments and to the men who design, apply and maintain them. In brief, the thesis of the article is that industry's "third horizon" is automaticity. Although the article deals only with continuous processes, it displays keen understanding of Instrumentation:—

Three basic technical advances are largely responsible for our industrial development according to H. H. Dow, late head of the remarkably successful Dow Chemical Company. First of these was the steam engine, inaugurating power production. Then came interchangeable parts, making possible mass production. Now comes a third advance still in its infancy,—automatic operation by automatic control of continuous processes. This advance bids fair to occupy a position in the process industries somewhat similar to that which the system of interchangeable parts holds in the assembly industries.

As early as 1894 an instrument was developed to indicate the amount of free chlorine being liberated in an electric cell operated to produce free bromine from brine. The instrument was based upon the fact that a higher voltage is required to liberate chlorine than bromine. As a next step these variations in voltage were used to vary automatically the rate of electrolysis of the brine, to reduce the liberation of chlorine. More recently a newly developed process demanded the maintenance of a correct ratio between two salts within an extremely narrow range during an oxidation process. Laboratory chemical analysis was obviously too slow, but it was found that the optimum ratio corresponded to a certain definite acidity. An instrument was then devised to record this acidity automatically by electrochemical means, and to actuate a motor-operated valve controlling the addition of raw materials.

These instances exemplify the manner in which automatic analysis has been rapidly developing in the process industries not for the purpose of saving a few hours of an inspector's time, but to reduce wear on equipment, to create substantial material and power economies, to cut operating time, simplify operations, improve quality and uniformity, and to make possible methods of production otherwise impractical. Automatic analysis is accomplished by a variety of means, including mechanical, thermal, electrical, electrostatic, electromagnetic, photo-electric, electrochemical and chemical measurements. These measurements may be used to actuate either continuous control mechanisms or merely "trigger" control (within tolerance limits).

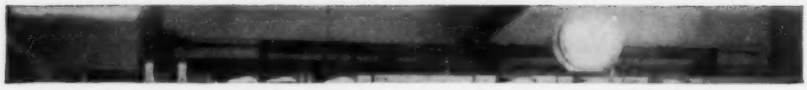
A mechanical device which, like a hydrometer, is actuated by changes in the density of a liquid is used to control within very narrow limits the composition of solutions containing constituents of different specific gravities, as in sugar solutions. Somewhat comparable devices are used for gaseous mixtures. Quite different is a rayon ribbon, suspended over but not touching a sheet of newsprint, which expands and contracts according to the moisture content of the newsprint.

A continuous measurement of the heat conductivity of gases in mixtures is used to determine very accurately the proportion of hydrogen or of other good heat-conducting gases present. Similarly, continuous measurement of the rise in temperature occurring when combustible gases in gaseous mixtures are burned with a known amount of oxygen is used in automatic analysis. The concentration of solutions is frequently measured electrically by a circuit including both a closed tube containing a sample of the desired concentration and an open tube through which the test liquid passes. Applications include automatic control of recirculating solutions in copper refining, and automatic direction of paper mill wastes to a concentrator or to discharge, depending on the value of the sodium salts present.

The thickness during manufacture of continuous sheets, such as paper or rubber, is measured by passing them between, but not touching, the plates of a condenser and measuring the change of capacity produced. Developments are in progress to apply this method to obtain tolerances of a millionth of an inch for gauges and for precision machine tools. The moisture content of paper, wood, cereals, etc., the fineness of aggregates, and the degree of dispersion of lampblack in rubber have been similarly determined. By exposure of the test material to a rapidly alternating electrostatic field a measure of the amount of work required to move the molecule within the substance is obtained, and this is useful in such applications as controlling the electrical properties of iron and the vulcanization of rubber. Electromagnetic measurements are sometimes used to determine stresses, hardness and flaws present in iron sheets.

Photo-electric measurements are used in the analysis of colored or partially opaque gases (including smoke) and liquids, and in some cases have been used with ultra-violet or infra-red rays for the analysis of materials which cannot be detected by visible rays. It is reported that the photo-cell is being used in a development to maintain a constant concentration of dye in a dye bath used in continuous piece dyeing, and to determine the finish, gloss and transparency of materials such as paper and fabrics. Photo-electric cells are also used with chemical indicators. A moving strip of lead acetate treated paper passed through a gas pipe is blackened if hydrogen sulfide is present; measurement of the degree of blackening indicates the hydrogen sulfide concentration. Other chemical indicators may be used correspondingly and photo-cells may also be used both to "see" indicator solutions more sharply than the eye is able to do and to stop the flow of titrating liquid when a given color value is reached.

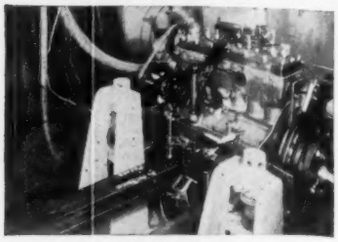
Acidity control, important in the fermentation industries and water treatment, is often accomplished electrochemically by immersing thin-walled glass-tube electrodes, one containing a solution of the desired acidity, in the liquid to be measured. A common example of automatic chemical analysis is carbon dioxide measurement, often made to indicate the completeness of combustion attained under boilers. The gaseous mixture given off in combustion is metered, passed through material to absorb the carbon dioxide, and again metered to indicate the volume lost.



720 R. P. M. ... *Yet this generator appears motionless when illuminated by .....*

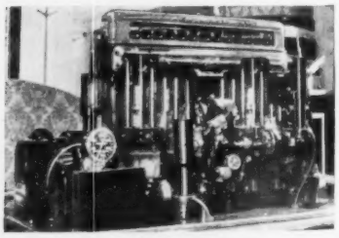
The **EDGERTON STROBOSCOPE**

This is graphic proof of the brilliancy and motion-stopping ability of the Edgerton Stroboscope. You, too, can use it for studying and demonstrating machinery behavior in slow motion at speeds as high as 20,000 or 30,000 r.p.m. Note these typical applications



RESEARCH

Chrysler Corporation's engineering laboratory measures the amplitude of crankshaft vibration as a function of engine speed



SALES

General Motors displayed Buick and Pontiac engines in stroboscopic slow motion at the New York Auto Show

PRODUCTION

The Edgerton Stroboscope checks the operation of a high-speed cable wrapping machine in the Simplex Wire and Cable Company's factory

This bulletin gives you all the facts!

The Edgerton Stroboscope is a practical commercial application of the familiar stroboscopic principle by means of which rapidly moving phenomena can be observed in slow motion. The compactness and portability of the unit, the unusual actinic brilliancy and short duration of the flash, and its ability to stop motion at high speeds makes the performance of this new stroboscope an outstanding industrial achievement.

A complete description of the stroboscope is printed in Bulletin Ex-3212. Uses are suggested, operating limits are defined, and other data presented upon which you can base further specific inquiries as to its application to your problems.

WRITE FOR BULLETIN EX-3212 TODAY

GENERAL RADIO COMPANY

Cambridge Mass.

Hygrometric Instruments "Say When"
to Lay Wood Floors Over Concrete Subfloors

By M. E. DUNLAP

Senior Engineer, Forest Products Laboratory,* Forest Service, U. S. Department of Agriculture

RECENT tests with rapid moisture-indicating instruments developed at the Forest Products Laboratory indicate a possible solution to the perplexing problem of the minimum time to allow between the pouring of a concrete subfloor and the laying of the wood finish floor, which problem has long puzzled the architect, engineer, and contractor.

After the wood floor is laid evaporation of moisture from the concrete is greatly retarded and the humidity in the space between becomes high if the concrete has not dried sufficiently. This condition frequently causes the dry wood flooring to swell and buckle, and sometimes results in wide, permanent, unsightly cracks. The moisture content of the concrete slab should therefore be carefully considered, particularly if the work is being rushed.

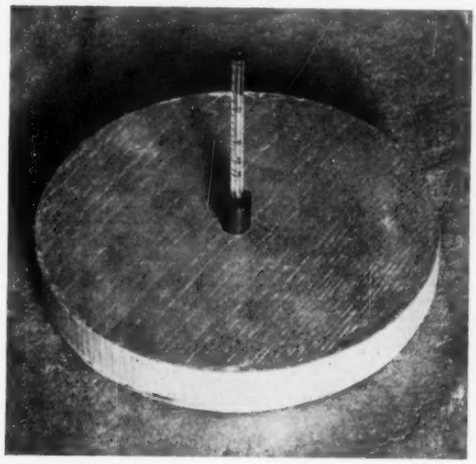


Fig. 1. Wood hygrometer with shield in place on a concrete subfloor.

No method had been available to the construction superintendent which would enable him to determine the minimum time. This led some architects and engineers to specify substitute materials instead of wood. The tests at the Forest Products Laboratory indicate that either a wood hygrometer, or a modification of it, or an electrical wood moisture indicating instrument, can be adapted for the rapid determination of the moisture content of concrete floor slabs so as to permit the laying of the wood flooring at the earliest possible date that will insure subsequent satisfaction.

*Maintained at Madison, Wis., in coöperation with the University of Wisconsin.

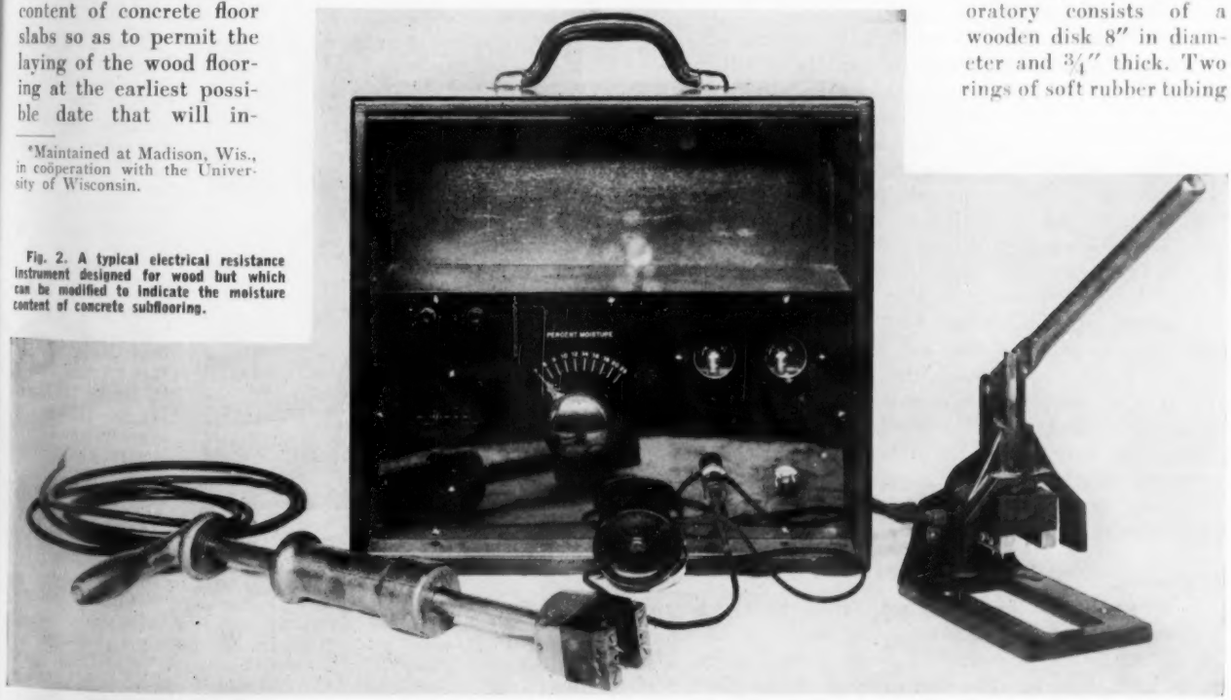


Fig. 2. A typical electrical resistance instrument designed for wood but which can be modified to indicate the moisture content of concrete subflooring.

Wood Hygrometer

The wood hygrometer will serve to determine the proper time at which to lay the wood flooring by indicating the relative humidity of a small enclosed space immediately above the concrete slab in terms of wood moisture content. The instrument consists simply of a piece of glass capillary tubing with a bulb of gold beaters' skin at the bottom containing mercury. This thin membrane responds to changes in humidity, causing the bulb volume to vary and the mercury in the capillary to rise or fall accordingly. The instrument indicates relative humidity in terms of wood moisture content. When not in use it is kept over anhydrous calcium chloride, which at ordinary room temperatures provides an equilibrium condition and serves as a check on the accuracy of the instrument. The entire instrument is housed in a cylindrical case and can be carried like an ordinary fountain pen. This instrument, originally designed to determine the moisture content of wood, is used to determine the dryness of the concrete subfloor by the addition of a moisture-proofed shield. The type of shield found most satisfactory in tests at the Forest Products Laboratory consists of a wooden disk 8" in diameter and ¾" thick. Two rings of soft rubber tubing

glued to the outer rim of the base of the shield provide a shallow air space above the concrete. The shield is protected with 3 coats of aluminum paint to prevent moisture changes in the wood. A stoppered hole in the center of the shield is provided for inserting the wood hygrometer (Fig. 1). The most reliable readings were taken by placing the shield on the concrete and leaving it over night, replacing the stopper with the hygrometer

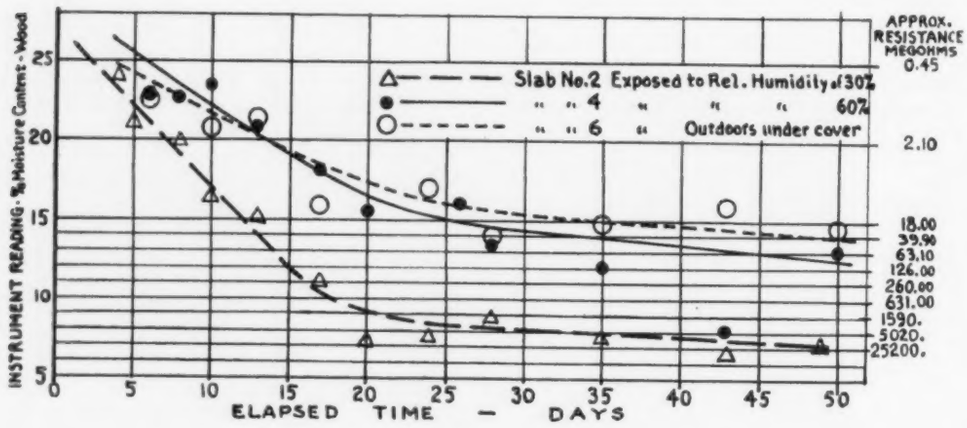


Fig. 3. Effect of drying upon the electrical resistance of concrete.

only 10 or 15 minutes before the readings were made. This instrument has not been developed commercially because of difficulties encountered in shipping it; however, a special instrument could be designed to measure the humidity without the use of mercury, which contributes very greatly to the shipping difficulty.

Electrical Instruments

The electrical resistance measuring instruments, also originally designed for use on wood, can probably be used with some modifications to obtain an idea of the moisture content of a concrete subfloor. There are several types of the portable electrical instrument now on the market for use with wood (Fig. 2). They are all based upon the well-known fact that the electrical resistance of wood changes with moisture content. The features common to the present instruments are two sharp metallic terminals that can be quickly embedded in the wood, batteries for supplying an electric current through the wood intervening between the two terminals, and a means for reading the resistance in the electric circuit directly in terms of the moisture content of the wood holding the terminals. In the event that an electrical instrument is used for concrete it will be necessary to cast electrodes in the fresh concrete. Measurement made on electrodes ½" in length are shown in Fig. 3, and indicate that it is possible to make electrical moisture content measurements as the concrete dries out. It is, of course, possible to expect some variation in the electrical resistance of different cements and aggregates, but it is more than likely that electrical measurements will be within a range that will permit the detection of unsatisfactory moisture conditions. Further experimental work should definitely show the effect of these factors on electrical measurements in concrete.

Application

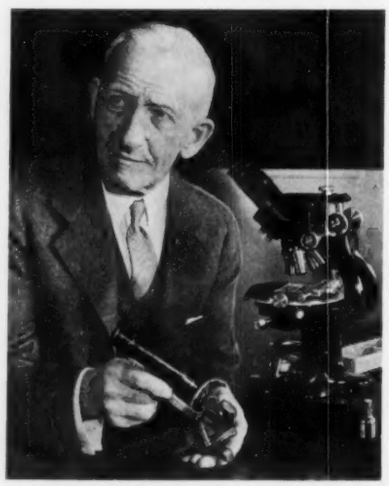
Either the wood hygrometer or an electrical moisture indicating instrument appears as a practical means of inspecting concrete floors over which wooden finish is to be laid. With an electrical instrument the placing of electrodes at the time the slab is poured is of importance, and the most suitable method is not known at present. As a method of trial a pair of ½" rivets could be pressed into the finish coat of cement with the heads flush with the finished surface of the floor and about 2" apart. Contact could be made later to the top of the rivets through the terminals of the electrical instrument.

The wood hygrometer method can be used without a great amount of further work. The shield should be made of wood or metal as shown in Fig. 1, should be at least 8" in diameter and have 2 lines of soft rubber tubing secured to the lower side of the shield.

To test the moisture condition of a slab the shield should be placed on the surface of the concrete after sweeping away any dirt or grit. A rubber stopper should be placed in the hole for the hygrometer and the shield weighted down with a brick or similar object to prevent interchange of air between the outside and inside. The shield should be undisturbed for 8 to 10 hours and the hygrometer then inserted. If at the end of 15 minutes the hygrometer does not register higher than 11% the concrete would be considered in a satisfactory condition for application of the finish wood floor. This figure, however, has not been established by a sufficient number of tests to definitely recommend it as the correct value to use under all conditions.

With some modification the apparatus described could probably be applied to plaster wall finishes also.

◈ ◈ ◈



Edward Bausch, President of the Bausch & Lomb Optical Co., was guest of honor at the annual dinner of the Society of the Genesee, January 23, at the Commodore Hotel, New York. Speakers included Major Gen. J. G. Harbord, Dr. Arthur Louis Day, Dr. Rush Rhees, Louis Wiley and John D. Rockefeller, Jr. Pres. Elon H. Hooker was toastmaster.

Bausch is one of America's early microscope builders, starting when there were only 18 microscopes in the entire country. He has been a leader in the invention of optical equipment and the development of mechanical means for producing it at a reasonable cost. Born in 1854, a stone's throw from the Genesee River, he has spent his long life building the enormous B & L plant upon its banks. The photograph shows him seated at the latest B & L research microscope and holding a microscope he built with his own hands 65 years ago.

The ENGINE INDICATOR

Its Design and Theory

(Continued from January Issue)

By KALMAN J. DeJUHASZ*

The *electric potential method d* is based on the so called piezo-electric properties of certain crystals, such as tourmaline and quartz in virtue of which an electric charge develops at their ends if subjected to tension or compression in an appropriate direction with reference to their crystalline axes. It has been shown that the electric charge is directly proportional to the acting force.

Utilizing this principle a pressure indicator has been developed in the German Bureau of Standards (Technisch Physikalische Reichsanstalt) by Kluge and Linckh.[13] In this a quartz crystal is used, enclosed in a pressure chamber (Fig. 89). The potential is measured by means of an electrostatic tube-voltmeter in connection with an electromagnetic oscillograph. The electrical set-up is shown in Fig. 89a and a set of diagrams in Fig. 89b.

The pressure unit consists of a steel chamber, containing two quartz crystals, which can be screwed into the engine cylinder. The direction of the pressure-force coincides with one of the electric axes of the crystals. The chamber has an elastic bottom which communicates the pressure forces to the crystals and protects them from electrical influences and also from humidity and impurities. The crystals are assembled with their faces of similar polarity in contact with the electrode *e*, as a consequence of which the two potentials are added. The cover is fastened with screws in such a way that there is an initial compression of the crystal. A steel ball acts as an equalizer of pressure. The measuring electrode is shielded by a metal tube and is connected to the voltmeter.

The bottom of the pressure chamber is about 0.01 in. thick and of 1⅜ in. diameter. A simple calculation shows that the forces are transmitted to the two crystals in practically undiminished magnitude. Denoting the elastic constant (force per unit of displacement) of the crystals c_1 and their change of length δ_1; that of the bottom c_2 and δ_2; that of the cover c_3 and δ_3, then of the total pressure force: $P = \frac{d^2\pi}{4} p$, the part P_1 will act upon the crystals and on the cover, while $P - P_1$ is balanced by the elastic force of the bottom. Therefore it can be written:

$$\left.\begin{aligned} P - P_1 &= \delta_2 c_2 \\ P_1 &= \delta_1 c_1 \\ P_1 &= \delta_3 c_3 \end{aligned}\right\} \text{ or in other form: } \left\{\begin{aligned} \delta_2 &= \frac{P - P_1}{c_2} \\ \delta_1 &= \frac{P_1}{c_1} \\ \delta_3 &= \frac{P_1}{c_3} \end{aligned}\right.$$

As $\delta_2 = \delta_1 + \delta_3$

$$\text{therefore } \frac{P - P_1}{c_2} = \frac{P_1}{c_1} + \frac{P_1}{c_3}$$

$$\text{whence } P_1 = P \frac{c_1 c_3}{c_2 c_3 + c_1 c_2 + c_1 c_3} = \alpha P$$

Substituting the actual values $\alpha = 0.998\ (=)\ 1$

A thin bottom is preferable because thereby the disturbing temperature effects in the crystal are avoided. If β_1 and β_2 are the temperature expansion coefficients of quartz and steel respectively and the temperature of the box is raised by Δt, then the temperature stresses on the quartz column of l length correspond to the force:

$$\Delta P = \frac{c_2 c_3}{c_2 + 4c_3} (\beta_1 - \beta_2)\, l\, \Delta t$$

For $\Delta t = 100^\circ$ C (180° F). $\Delta P = 0.1$ kg, corresponding to 1/100 atm. when the dimensions of the block are considered. The natural period of vibration is approximately 0.00001 sec.

Another piezo-electric indicator developed by Watson and Keys[14] utilizes a series of quartz crystals suitably mounted in a holder (Fig. 90a). The steel block *ABC* is threaded on one end to fit a spark plug opening and its other, bifurcated, end is formed to receive a spark plug and the crystal system. The steel diaphragm *D*, about ⅛ in. thick, closes the opening and transmits the pressure wave to the crystal system composed of the two end blocks *E* and *G*, made of steel, and of the six quartz

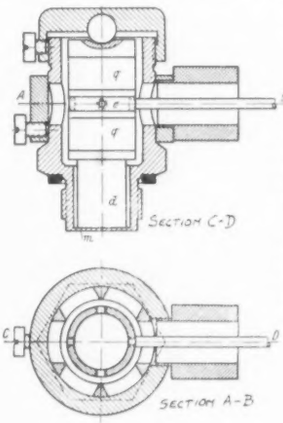
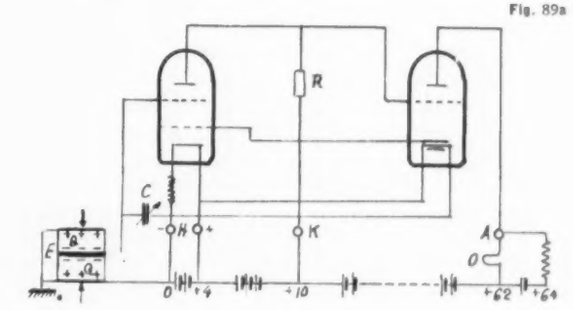


Fig. 89. Piezo-electric Indicator of Kluge and Linckh. The pressure acts upon the weak diaphragm and the force is transmitted to two quartz crystals *q* with a conducting metal plate *e* nipped between them. The resulting piezo-electric current is magnified by means of electron tubes shown in the circuit diagram Fig. 89a and it is recorded by means of an oscillograph. Fig. 89b shows the diagram taken from a gasoline engine at 690 r.p.m., I Suction; II Compression; III Expansion; IV Exhaust.

Fig. 89a



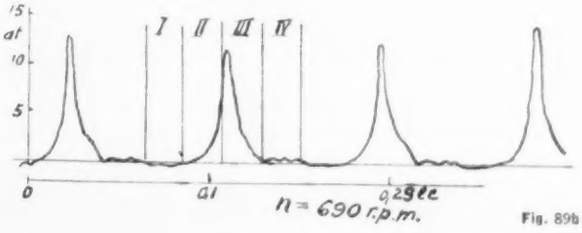


Fig. 89b

*Ass't Prof. of Engineering Research, Pennsylvania State College.

[13] J. Kluge & H. E. Linckh. Piezo-elektrischer Indikator für schnellaufende Verbrennungsmotoren. *Zeitschrift des Vereines deutscher Ingenieure*, Vol. 74, June 21, 1930, pages 887-889.
J. Kluge & H. E. Linckh. Messung mechanischer Grossen mit dem piezo-elektrischen Methode. *Forschung*, Vol. 2, May 1931, pages 153-170.
Sh. Watanabe. Cathode-Ray Oscillograph and Piezo-electricity. *Proceedings of the World Engineering Congress*, Tokyo, 1929, Vol. 5-6, pages 141-156.

[14] H. G. I. Watson & D. A. Keys. A piezo-electric method of measuring the pressure variations in internal combustion engines. *Canadian Journal of Research*, Vol. 6, March 1932, pages 322-331.

crystals, 3 mm. thick and 25 mm. dia. which are separated by pieces of lead foil. The whole unit is housed in the bakelite-lined steel tube *JJ* and can be compressed by the set screw *H*. The crystals are inserted with their sides of the same polarity facing each other. Therefore four of the lead foils become positively, the other three negatively charged whenever the unit is compressed. One set of lead foils are grounded while the other set is connected to the terminal *K*. The pressure changes in the engine are thus transformed into proportional variations in the potential of *K*. It is stated that the natural period of vibration of the unit is of the order of 10^{-5} sec. The potential to which the terminal *K* is raised by a given pressure depends upon the number of crystals used. There is, however, an optimum number *n* at which the voltage of the system is maximum for a given pressure. Given the usable total length of the column *l*, determined by constructional limitations, the thickness of one quartz disk will be l/n. Denoting the area of the disk *A* and the dielectric constant of the quartz *k* the capacity *C* of one crystal can be expressed (neglecting edge effects):

$$C = \frac{k\,A}{4\pi\,l/n} = Hn$$

and the capacity of *n* crystals in parallel:

$$nC = Hn^2 \quad \text{where } H = \frac{k\,A}{4\pi\,l} = \text{const.}$$

Denoting the charge of one crystal *q*, that of *n* crystals *nq* and the external capacity C_x the voltage can be expressed:

$$V = \frac{nq}{n^2H + C_x}$$

Solving for the maximum of this function we find that it occurs when $n^2H = C_x$ i.e. when the capacity of the battery equals the external capacity. In the actually built unit only six disks were used resulting in the capacity of 60 micro-microfarad as this was the largest number that could be put into the space the quartz available being 3 mm. thick. About four times this number would have been better but would have necessitated the use of thinner disks with an increased danger of fracture. Also the leakage over the disks would increase with an increased number.

In order to keep the leakage effect small the crystal unit is shunted with a mica condenser having a capacity variable from 0.001 to 0.006 microfarad. This reduces the potential of *K* produced by the pressure and consequently the error caused by the leakage becomes proportionately lower.

The small potential-variations across the condenser produced by the charge of the crystals must then be amplified and applied to the deflecting plates of the oscillograph.

The amplifier (Fig. 90b) is of the two-stage, resistance-coupled, aperiodic type in which the first stage consists of a bridge-type arrangement. This arrangement minimizes the disturbing effects of changes in battery potential, filament-operating current and other extraneous error sources and makes it possible to keep the valves working on the straight-line range of their characteristics. On the illustration the crystal system is shown at *C* and the condenser in parallel at C_x. Variations across the condenser change the potential of G_1, the grid of the valve T_1. This throws the "bridge" out of balance with the result that the potential of G_3 is altered causing a change in the potential across the resistance R_3. By operating the tubes on the straight line portion of their characteristic curves it is possible to obtain a constant amplification factor for the range of

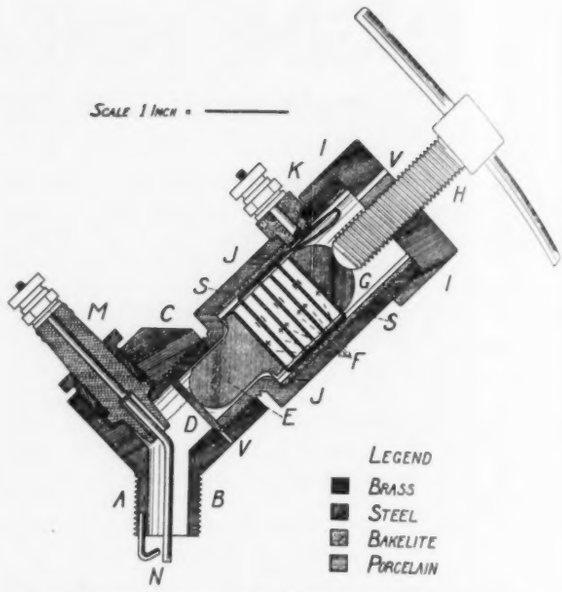


Fig. 90a. Piezo-electric indicator of Watson and Keys. M spark plug; E and G end blocks; F quartz disks; K terminal; D gasket plate; S Bakelite lining.

potential assumed by C_x due to the pressure variations in the engine. One pair of deflecting plates of the oscillograph is connected across the resistance R_3, a number of the cells of the battery B_3 being included in order to keep the spot, caused by the cathode-ray beam of the oscillograph, on the screen. The key and high resistance galvanometer *G* are included in the circuit for testing the balance of the bridge circuit, the necessary alterations in R_1, R_2, X_1, X_2 and c_2 being made so that small changes in plate battery voltages, and in the main battery rheostat, do not change the current through the galvanometer (which need not be necessarily zero). The potentials of the batteries c_1, c_2, c_3 *and* c_x could be varied. R_1 and R_2 are made 150,000 ohms each. R_L is 100 megohms X_1 and X_2 being small adjustable resistances for compensating any small variations in filament battery voltages. R_3 is 100,000 ohms. The battery voltage B_1 B_2 is 180 volts, and B_3 also 180 volts, of which about 100 were included in the oscillograph circuit. The characteristics of each valve were determined and they were operated on the linear portion of the plate current-grid voltage curve. Since the apparatus was calibrated *in situ*, the actual amplification of the system need not be known.

The Oscillograph was of the low voltage cathode-ray type developed by J. B. Juhnson, as supplied by the Western Electric Company. This instrument is provided with two pairs of deflection plates very nearly at right angle to each other. The one pair is connected to the amplification terminals *NM* (Fig. 90b). This pair was so arranged that the deflections were in the vertical plane. The vertical deflection of the spot on the screen was thus proportional to the potential across *NM*, and this in turn was directly proportional to the potential across the capacity C_x, which varies, as already stated, as the cylinder pressures in the engine. The second pair of plates in the oscillograph is connected to the timing device and these plates cause the spot to move in a horizontal direction with uniform velocity. The timing could be altered so that the time required for the beam to swing from one end of its path to the other agreed with a single cycle of the engine, and thus a time-pressure pattern, which would appear stationary to the eye, would be traced on the screen. By having the oscillograph in a dark room,

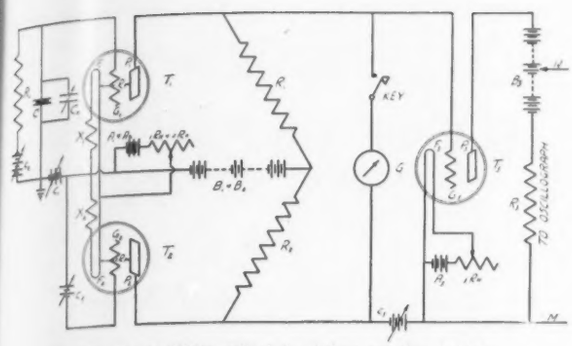


Fig. 90b. The amplifying unit of the Watson and Keys indicator.

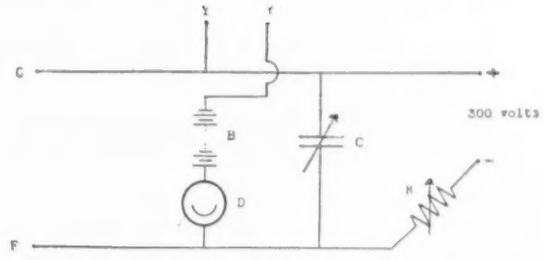


Fig. 90c. Time scale circuit of the Watson and Keys indicator.

it was found that the amount of light from a single transit of the beam on the willemite screen was sufficient to leave a record on a photographic film placed with its sensitive side directly against the glass screen of the oscillograph.

The Uniform Timing Circuit used is shown in Fig. 90c. The terminals F and G are connected to the time deflection plates of the oscillograph, G being the common terminal of the plate system. D is a voltage regulating tube of the "Radiotron" UX 874 type. B is a battery, the voltage of which can be varied from 90 to 135 volts, to regulate the mean voltage across the condenser C which is also the potential across FG, in order that the cathode-ray beam will describe a path symmetrically, between the two deflecting plates of the oscillograph, of the proper length. The capacity of the condenser C is variable between 0.001 to 1000 microfarads. The terminals YY were short circuited during an exposure, but a contact on the flywheel of the engine could be inserted between YY in order to give on the oscillograph the position of the piston with respect to the time scale. A 300 volt battery connected in series with a variable high resistance R (0.02 to 20 megohms) was connected across the condenser C. We thus have the equation for the voltage V across the condenser C at any time t from the moment the battery is connected given by

$$V = E\ (1 - e^{-\frac{t}{RC}})$$

where E is the total potential of the battery (300 volts), C the capacity of the condenser and R the resistance. By altering the values of R and C, the time constant of the circuit may be arranged so that the periodicity of the breakdown of the tube D will coincide with the period of the cycle of the engine. By the choice of this resistance and capacity with the voltage of E being 300 volts, only the first part of the exponential growth curve is used and this may be made to approach a linear relation very closely. In the apparatus used it was practically linear within the limits of the experimental error in measurement.

With this timing device stationary pictures of the time-pressure curve were obtained on the oscillograph when the engine was running at an uniform speed. It was found incidentally that the regularity of the neon voltage regulating tube was much improved when the tube was illuminated with the light of a 40-watt lamp. This was apparently due to a small photo-electric effect which made the tube break down with precision when a definite potential was reached. Such a lamp was placed beside the Radiotron tube, and the whole enclosed in black cloth to keep the room dark during the taking of a photographic record.

The apparatus is calibrated by means of a pressure gage tester. After applying the desired pressure the charge was removed from the oscillograph plates and the pressure suddenly released by opening a valve. Under these conditions the charge produced on the quartz disks will be equal, but of opposite sign, to that produced by applying the same pressure. Since the pressure can be released more rapidly than it can be applied, this method of calibrating has the advantage of greatly reducing the time available for leakage. The deflection of the spot on the oscillograph was then measured for a given pressure. The resulting calibration curve was found to be practically linear. This method of calibration eliminated the necessity of determining the amplification factors, capacity of the system and other constants since all these quantities remained unchanged.

It is suggested by Watson and Keys that the new Von Ardenne cathode ray oscillograph would be more suitable for application of this kind owing to the greater intensity of its beam.

One important limitation of the electrical indicators is, that the pressure values are recorded on a time basis and there is no provision for taking pressure-volume cards. For fundamental research the pressure-time cards are, as a rule, preferable, but in many cases pressure-volume cards are also desirable to obtain without the inconvenience and error involved in replotting.

Recently, with the Obata indicator, successful attempts have been made to remedy this shortcoming, by giving the electron ray of the cathode tube a second displacement, perpendicular to the displacement by the pressure, proportionately to the displacement of the engine piston.

Generally speaking, the electric indicators are more or less delicate instruments, to be used chiefly under laboratory conditions with great skill and care. In the hands of skilled investigators, however, their use often yields results otherwise unobtainable. It is probable that in the future their design will be improved in order to make them rugged enough for use in the workshop or ordinary testing room. The carbon resistor type of electric indicator, which is commercially obtainable, already shows a promise in this direction.

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Flow Measurement and Control*

By M. F. BEHART†

CHAPTER XXIII
POSITIVE METERS

7. Liquid Displacement Meters

(c) Reciprocating Piston Types

(Continued)

Twin Tandem Cylinder—Yoke Connection

In this type of reciprocating piston meter, there are four pistons—two sets of two, with a 90° phase relation to each other, exactly as in the crossed-cylinder types just described. Instead of one rotary valve serving both cylinders, however, each set of pistons has its valve, properly timed and with accelerated motion at piston dead center.

The *Micro Meter* high and medium pressure meters (Oil Conservation Engineering Co.) belong to this type. Fig. 23-30 shows how the 90° phase relation is obtained in these two models by means of crank wrists working in yokes. The medium pressure Micro Meter, Fig. 23-31, has balanced slide valves.

Fig. 23-30

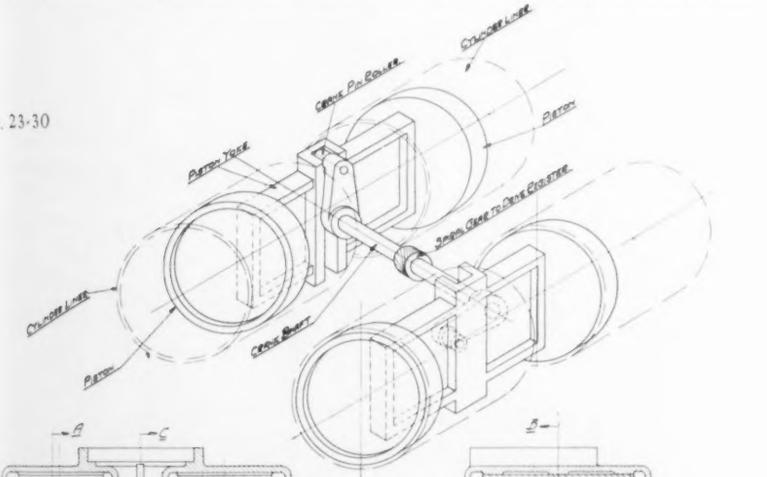
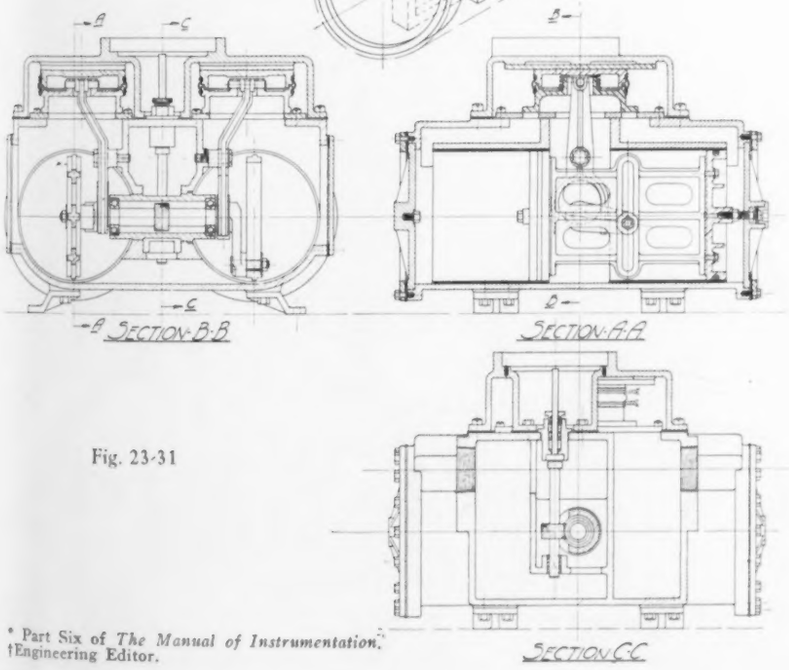


Fig. 23-31



* Part Six of *The Manual of Instrumentation.*
†Engineering Editor.

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Dial and Mercury column types...These Indicators are applicable for indication of flow-rates of water, oils, chemicals, air, gas and steam under wide range of conditions

Maximum W.P.–Dial type..... 250 lbs.
Maximum W.P.–Mercury type 2000 lbs.

Both types used with MJL Orifice and Flanges...*Write for complete literature.*

MOREY & JONES, Ltd.
Manufacturing Engineers
923 So. Hemlock St., Los Angeles, Cal.

MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

A28 **Control Switch.** A control switch used for pressure, vacuum, and temperature is described in Bulletin No. 54 issued by the Detroit Lubricator Co., Detroit, Mich.

A29 **Electric Counters.** "The Electric Eye" which is a combination of electronic cells and magnetic counters is described in a four page bulletin. Production Instrument Company, 1315 S. Wabash Avenue, Chicago, Ill.

A30 **Lubrication of Small Mechanical Devices.** No. 102.3 of this bulletin pertains to the application of colloidal graphite to industry. Acheson Oildag Company, 654 Madison Ave., New York.

A31 **Tensile Testing Machine.** A 15 page illustrated publication devoted to oxweld portable tensile testing machine. The Linde Air Products Co., 205 East 42nd Street, New York, N. Y.

A32 **Radio Products.** Circular 507 covers various Vitrohm radio products. Ward Leonard Electric Co., Mount Vernon, N. Y.

A33 **Optical Instruments.** Catalogue L-1 describes and illustrates spectrometers, X-ray spectrometers, spectroscopes, spectrophotometers, accessories. The Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

A34 **Densitometers.** A leaflet describing a densitometer designed for measuring the absorption, respectively, blackness or density of photographic negatives. Akatos, Inc., 114 Liberty St., New York.

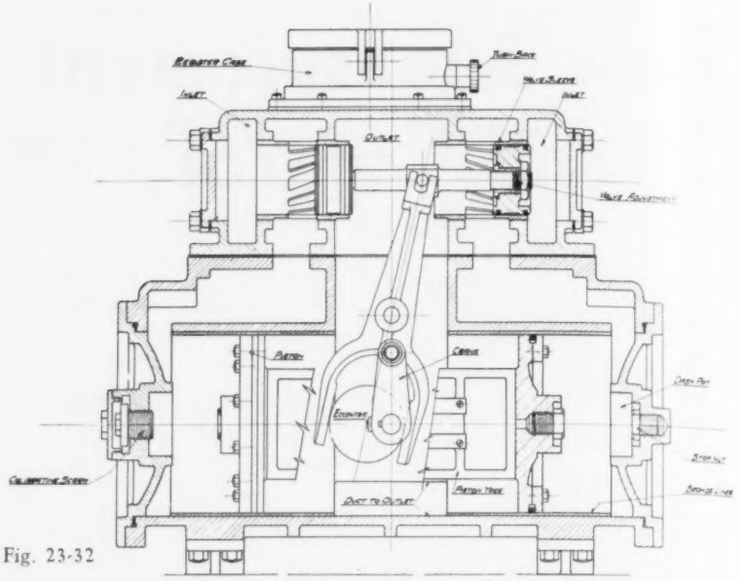

Fig. 23-32

The high pressure model, Fig. 23-32, differs from it chiefly in that it is provided with piston valves. Both of these meters have been brought out shortly before this writing (1933). Literature is not out yet but the makers have furnished the following data:

	Medium pressure model	*High pressure model*
Max. capacity, g.p.m.	300	300
Inlet and outlet pipe size	3"	3"
Max. working pressure, lb per sq. in.	150	800
Test pressure, lb per sq. in.	600	2000
*Limit of error at normal flow	(<errors of observation)	
* do at 1% of capacity	0.5%	0.5%
* do at 1/10% of capacity	1%	1%
†Pressure loss at capacity flow	approx. 8 lb	approx. 12 lb
Weight, lb	600	800

*When metering low-viscosity, low gravity, liquids, such as gasoline. Smaller errors when metering heavy oils.

†When metering heavy oils. Smaller loss when metering low-viscosity, low gravity liquids.

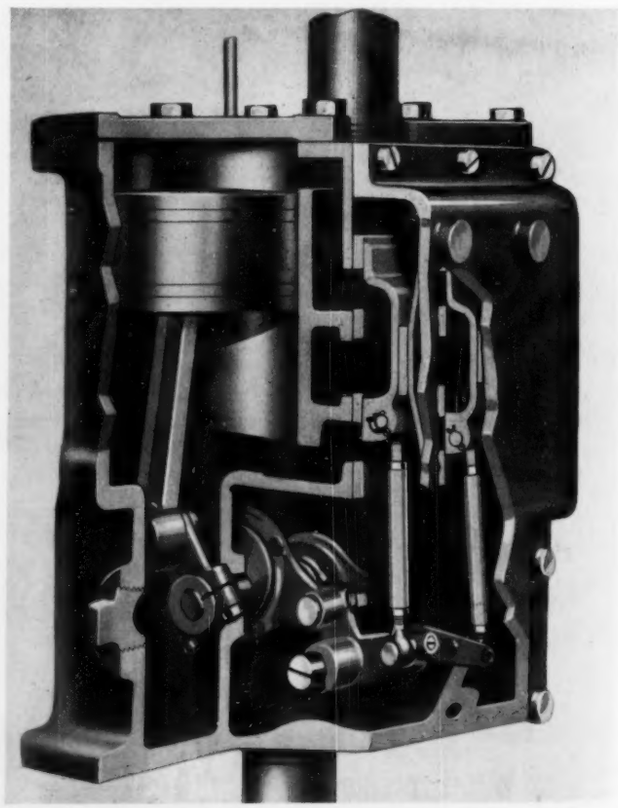

Fig. 23-33

Various styles of registers can be attached, the standard style having a 6" dial representing 10 gallons, a visible 5-digit reset counter and an 8-digit totalizing counter under key-operated blind. Optional features are as follows: (1) Automatic compensator for temperature of metered liquid; (2) Manually adjusted compensator for gravity of metered fluid; (3) Rate-of-flow indicator; (4) Remote-reading instruments.

Double-acting Twin Cylinder—"Engine Type"

This type has the familiar features of a conventional two-cylinder steam engine, namely, connecting rods and crankshaft, eccentrics on crankshaft, unbalanced slide valves driven by the eccentrics.

Fig. 23-33 shows the low-pressure model of the *Micro Meter* (Micro Meter Corp.) and requires no explanation, since the reader knows how a slide-valve engine works; but there is of course the difference that on account of the incompressibility of the metered fluid there is no expansion period, both admission and cut-off points occurring at dead-center. This is the original model of the Micro Meter (1930) and its general characteristics differ only from those of the later medium-pressure model described above in that it is designed for dispensing service and gravity discharge or low-head applications.

Fig. 23-35 shows the *Pittsburgh 1" Oil and Gasoline Meter* (Pittsburgh Equitable Meter Co.) which differs from the conventional engine chiefly in that it employs a rotary instead of a reciprocating slide valve. Its capacity range is 0.05 to 25 g.p.m. Its pressure loss for maximum rated flow is 4.3 lb. It weighs 45 lb in iron case and 20 lb in aluminum case, the maximum line pressures for these cases being 150 and 10 lb per sq. in. respectively.

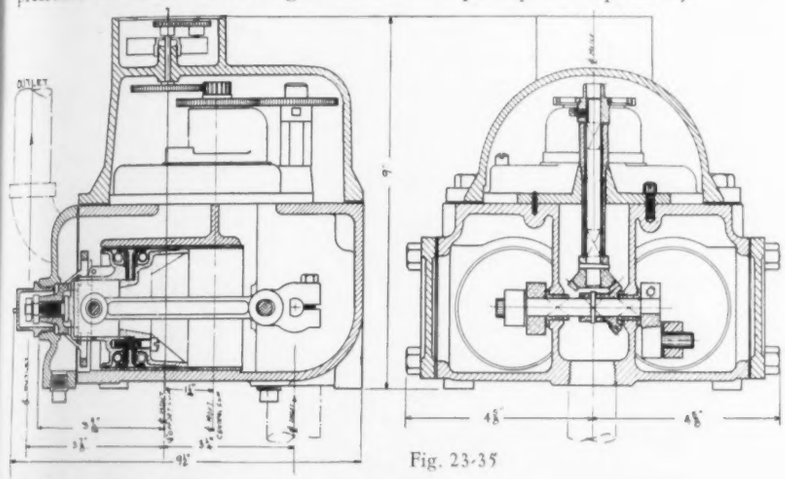

Fig. 23-35

Tandem Cylinder—90° Crank—Rotary Valve

This type of reciprocating piston meter has two pistons working in one cylinder. This cylinder breaks off in its middle so that strictly speaking, it is two cylinders lined up in the tandem. The two pistons do not move together, as do the sets or pairs of pistons in the cross-cylinder and twin-cylinder types just described, but they are in 90° phase relation by reason of a crankshaft in the center space between the two halves of the tandem cylinder. This same crankshaft serves as a valve shaft for two rotary valves.

The crankshaft need only be perpendicular to the axis of the cylinder. It might be horizontal, but in the commercially available meters of this type it

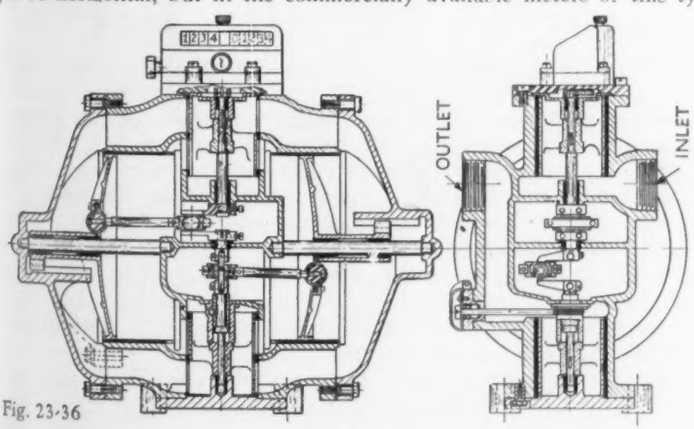

Fig. 23-36

A35 **Spectrum Analysis.** Bulletin No. 4 contains information on biological applications, metallurgical and chemical applications, and absorption spectrography. Adam Hilger, Ltd., London N. W., 1, England.

A36 **Portable Hardness Tester.** A circular describing a light portable device known as a porable Brinell hardness Tester, which efficiently solves the problem of making tests, according to the Brinell method. Tinius Olsen Testing Machine Co., 500 North Twelfth St., Philadelphia, Pa.

A37 **Recording Instruments.** Bulletin 416 describes recording electrical instruments. The Bristol Co., Waterbury, Conn.

A38 **Laboratory.** Volume 5 No. 5 of this publication contains a very interesting article on the "Gaper" the old symbol of the Dutch Chemist's Shop. Fisher Scientific Co., Forbes St., Pittsburgh, Pa.

A39 **Tube Tester.** A circular describing an English-Reading Tube Tester. C. W. Burton, Burton-Rogers Co., 755 Boylston St., Boston, Mass.

A40 **Grade-O-Meter.** A 4 page circular describing a Grade-O-Meter which is a precision instrument capable of grading grinding wheels with micrometric precision. Abrasive Engineering Corp., 8605 Puritan Ave., Detroit, Mich.

A41 **Cathode Ray Tubes.** A circular describing cathode ray tubes useful for the observation and recording of phenomena where high frequencies and very short time intervals are involved. Allen B. DuMont Labs., Upper Montclair, N. J.

A42 **Cathode Ray Oscillograph.** A circular featuring cathode ray oscillograph and associated equipment. Allen B. DuMont Labs., Upper Montclair, N. J.

A43 **Solenoid Water Valves** are described in a circular issued by the Automatic Products Co., Milwaukee, Wis.

A44 **Flow Controller.** A broadside featuring the fifteen advantages of the Magnetic Clutch Flow Controller. C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

A45 **Insulation Tester.** Bulletin 1350 describes the Midget "Megger" Tester used for testing electrical insulation. James G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

A46 **Recording Chart.** A circular issued by The Taylor Instrument Companies illustrating an extra-wide scale chart for mercury-actuated recorders.

A47 **Radio Meters.** A 20-page booklet printed in October, 1932, describes radio meters for A.C. and D.C. Measurements. Ferranti, Inc., 130 West 42nd St., New York.

A48 **Cycle Controller.** Catalog F-61 is devoted to automatic sign flashers manufactured by the Leland Electric Co., Dayton, Ohio.

A49 **Microscopes.** A 19-page booklet identified as List No. M7 describes and illustrates various kinds of microscopes made by Negretti & Zambra, 38 Holborn Viaduct, E.C.1, London, England.

A50 **Contact Controls.** Catalog 11850 issued by the Taylor Instrument Companies shows electric contact controls for temperature and pressure.

A51 **Spectrometer.** Publication No. 175/2 describes a simple eyepiece attachment known as the "Insta" for a spectroscope. Adam Hilger, Ltd., 98 King's Rd., Camden Road, N.W.1, England.

INSTRUMENTS, 3619 Forbes St., Pittsburgh, Pa.

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

.....

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Name.....

Position.....

Firm.....

Street and No.....

City.....State.....

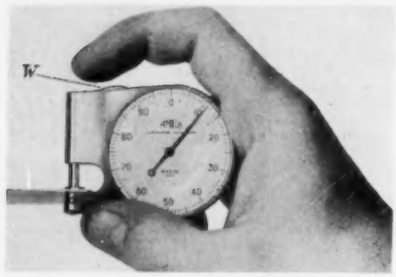
NEW INSTRUMENTS

Write Information Section, Instruments Publishing Company, for additional information.

Speedy Thickness Gage

B. C. Ames Co.

LOW price was one of the aims in bringing out this new gage, and was attained without impairing accuracy. The "Ames Thickness Measure" is thin, light, free from sharp corners or projecting parts, made of non-rusting metals and with an unbreakable crystal. It is easy to use, the spindle being raised



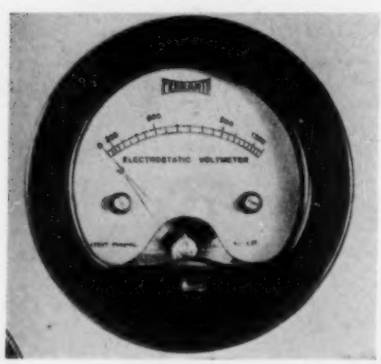
by turning the knurled wheel W and the anvils closing with uniform spring tension when wheel is released. The dial is graduated in thousandths. Guaranteed accuracy is within 0.0005 in. Decimal conversion table is stamped on back.

◈ ◈ ◈

Electrostatic Voltmeter

Ferranti, Inc.

ESSENTIALLY a variable condenser, this new instrument affords a convenient means of measuring high a.c. and d.c. voltages in high-resistance circuits where considerable error is introduced by current-consuming voltmeters. Being self-contained, it is lighter and smaller than combinations of instruments with transformers or resistances. It is entirely free from wave-form, frequency and temperature errors. Damping is magnetic. Safety resistance is optionally embodied where a flash-over may occur. Lowest of the 9 ranges is 0-450 volts; highest is 0-3500 volts. Instrument styles are portable, flush, and projecting.



is vertical in order to permit interchanging various styles of registers at the top. Fig. 23-36 shows two sectional views of the *Brodie Universal Model U* (Ralph N. Brodie Co., Inc.). The liners of the rotary valves have been inked in black, to make these drawings more nearly self-explanatory. Note that each half of the meter is double-acting. In the longitudinal view the left-hand piston is at dead-center, its inner side still connected to the inlet and its outer side still connected to the outlet—just before the valves change over; the right-hand piston is at mid-stroke; its inner side is discharging and its outer side filling.

This model is made in 1¼", 1½", 2", 3" and 4" pipe connection sizes, the maximum capacities being 30, 50, 140, 300 and 500 g.p.m. of gasoline (approx. 50% of these capacities for heavy oils). The 2" meter weighs 130 lb; the 4" weighs 975 lb. A rate-of-flow indicator (modified cup-form automotive speedometer) is optional equipment. The centrally-guided pistons are not provided with rings, and in other respects these meters are apparently intended primarily for rapid dispensing service—not for accuracy at extremely low rates of flow. It is evident that the purpose of the designers was to minimize the pressure loss, and this has been realized, judging from the remarkably low absorption curves for all sizes. Stroke length is adjustable. A properly adjusted meter should show negligible errors at normal rates of delivery when the temperature and properties of the metered liquid do not change, inasmuch as the registration curve "within the operating range is practically a straight line, the maximum variation being ⅛%" according to the makers.

Duplex Cylinder—Valveless

This is one of the oldest types of reciprocating piston meter, one form having been brought out in Germany some sixty years ago. The pistons (or plungers) cover and uncover ports in the cylinder walls.

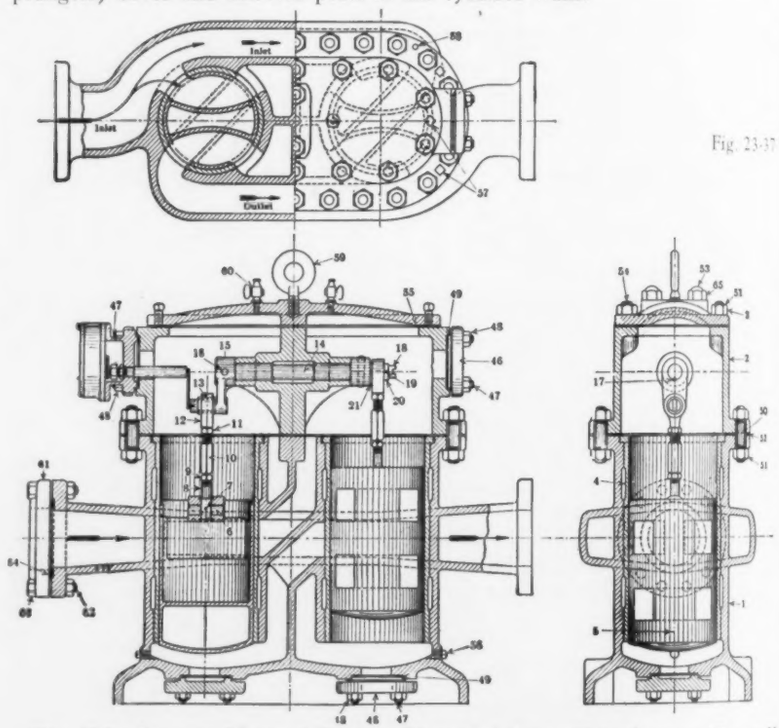


Fig. 23-37

The *Worthington Vertical Duplex Plunger Meter* (Worthington Pump & Machinery Corp.) is shown in Fig. 23-37 which is self-explanatory. Note that it is single-acting. Stroke length is positive and non-adjustable, but connecting rod length is adjustable—though not from outside (see parts 8, 9, 10, 11, 12). This meter was designed especially for measuring oils under pressures up to 300 lb and temperatures up to 400° F. Its capacity is 400 g.p.m. of a 100-sec. Saybolt oil at 300° F. Size, 6" pipe connection; weight, 2960 lb.

Brodie Universal Model X (Ralph N. Brodie Co., Inc.). This meter may be said to be of the type now being considered, but each of its four pistons is double-acting—which design results in a satisfactorily uniform delivery. The pistons are centrally guided and unprovided with rings. The meters therefore register "slow" at low rates of flow, and changes in temperature, etc., cause errors, but the registration curves are practically straight throughout the "operating range" of each meter so that extreme accuracy is attainable with

normal flow of a homogeneous liquid; moreover the pressure loss is so low that these meters, according to the makers, "will start and operate on as low as 1" head" and will give unusually high delivery speed whether operated under gravity or pump pressure.

These model "X" meters are made in seven sizes from ⅜" to 6" pipe connection; with maximum capacities 8 to 1000 g.p.m. of gasoline (or 4 to 500 g.p.m. of heavy oil); weights 4 to 1500 lb; various styles of registers; optional equipment including rate-of-flow indicators, etc.

Wobble Plate Type

The distinguishing feature of this type is a circle of parallel cylinders below which is a round plate. Each piston rod is attached by a ball-and-socket joint to a point near the edge of the plate. The plate—and this is important—is prevented from rotating. Its degrees of freedom thus limited, the only kind of continuous motion it can execute is nutation—like what a spun coin does just before coming to rest on a flat horizontal surface.* An interesting characteristic of this design is that the amplitude of the nutations of the wobble plate governs the stroke length of all pistons. This amplitude is adjusted by raising

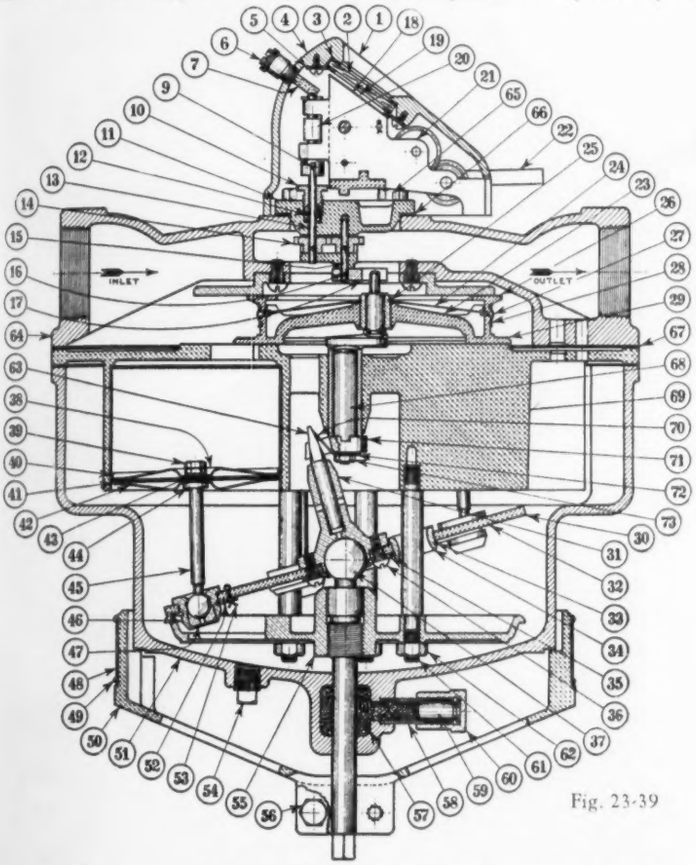


Fig. 23-39

or lowering the center of the wobble plate with reference to the horizontal surface with which the low point of the wobble plate is always in rolling contact—a principle employed for many years in hydraulic transmissions such as the ingenious battleship turret gear. This is done by raising or lowering the ball which fits into the central socket of the wobble plate. This ball forms the upper end of a short shaft resting on an adjusting screw. Turning this screw, therefore, changes the stroke length of all pistons. Inasmuch as the head of this screw protrudes through the bottom of the meter body, it is possible to regulate the registration of the meter while it is in operation.

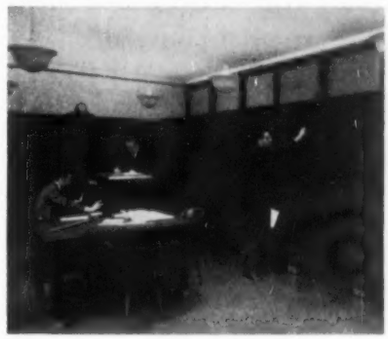
The *Xacto Meter* (S. F. Bowser & Co., Inc.), brought out in 1929, represents this type. Its standard models have five cylinders—a number which seems to have been arrived at as the best solution of the geometrical problem of achieving compactness and minimum weight for a given capacity. Fig. 23-39 is a sectional view through the center of the meter and the diameter of one of the cylinders. The principal parts are the cover assembly or top section, the center section or cylinder block assembly, and the bowl or lower housing. (Part No. 51 is the bowl; part No. 50 is a dial clamped to the adjusting

*But without rotating—as a coin continues to do in that familiar illustration.

A-C. Calculating Board Now in Regular Use

Westinghouse Electric & Mfg. Co.

STUDIES of power flow, regulation, losses, power factor and system stability are made quickly and easily on the alternating-current calculating board illustrated. Recently installed in the engineering department of the Commonwealth Edison Co., Chicago, it is



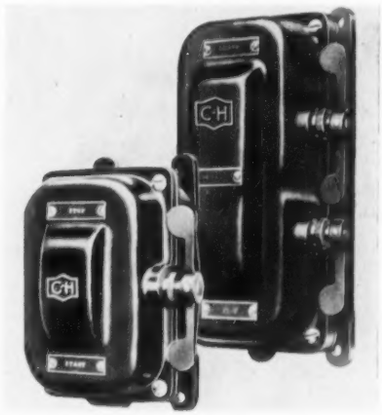
said to be the first to be placed in regular use by an operating utility. It operates on a frequency of 440 cycles. On it can be reproduced in terms of circuit constants the whole or any part of the Commonwealth Edison a.c. system.

◆ ◆ ◆

New Lever Operated Master Stations

Cutler-Hammer, Inc.

FOR use under severe weather or atmospheric conditions, a new line of master stations are operated from levers placed on the side of the case, instead of from push buttons on the front. It is claimed that by this unusual construction, an absolutely watertight case is secured. The shafts of the levers oper-



ate through stuffing boxes, and the cover joint is sealed by a rubber gasket. The stations use standard, heavy-duty, push button elements, mounted on removable individual moulded bases, fully enclosed. The stations are supplied in all normal ratings in one button (On and Off)—two button (Start and Stop)—or three button (Hoist, Lower, Stop).

Improved Humitrol

Lewis Air Conditioners, Inc.

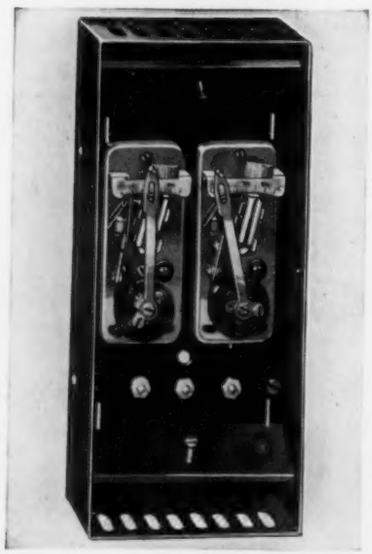
BOTH cover and base are of dark walnut Bakelite in this new model room-humidity controller. The purpose of this instrument is to put into operation dehumidifying equipment when the relative humidity in the room or rooms rises above the percent for which the Humitrol is set. Its inner mechanism has undergone refinements but the principle remains the same: a 21″ long ribbon of hygroscopic material causes a mercury switch to tilt one way or the other as the humidity varies. This ribbon passes over four rollers so that the length of the working unit is approximately 6″ and the instrument itself is 7⅞″ overall. Each Humitrol is factory-calibrated for an operative setting of ± 3% relative humidity. The mercury switch handles 2 amps. at 110 volts a.c. or d.c. For operating air-conditioning apparatus requiring more energy, relays are furnished.

◈ ◈ ◈

"Infiltration" Thermostat

Central Heat Appliances

PLACED on the inside surface of an outside wall—preferably near a radiator and beside a window, this room thermostat controls room temperature from two elements: one which responds to the air temperature in the usual way and a second one which "feels the cold coming through the wall." Adjustment of the relation between the two elements is provided for, in order to suit insulating properties or wind exposures of different walls. The regular model is electric; but a pneumatic thermostat is also furnished.



screw.) Fig. 23-40 is a lower view of the top section; Fig. 23-41 shows the center section viewed from above and Fig. 23-42 shows it viewed from below.

"A port is provided in the top of each cylinder. A ring-like double-faced rotating valve causes these ports to be in turn intake and discharge ports. All the flow on the outside of this valve is intake; all the flow up through the inside of the valve is measured liquid discharged from the cylinders.

"The liquid enters the meter through the inlet port and fills each cylinder in turn. When the liquid has forced the piston to the bottom of the stroke, the intake port is closed by the rotating valve, the discharge port is opened, and the contents of the cylinder discharged. The valve wipes across the top of each cylinder so that there is an exact quantity of liquid in that cylinder.

"The flow of the liquid itself forces each piston to the bottom of the stroke, and at the same time discharges a corresponding amount from the cylinder on the opposite side of the wobble plate.† Meters are set for accuracy by means of the adjusting screw (see Fig. 23-44). By turning this screw the central ball and socket joint on which the wobble plate operates is raised or lowered, thus shortening or lengthening the stroke of the pistons and putting a larger or smaller amount of liquid through the meter on each cycle of operation."

Fig. 23-40

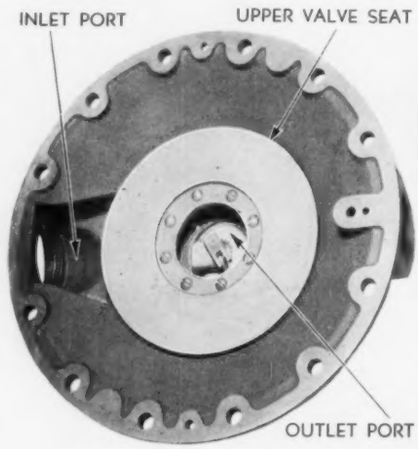
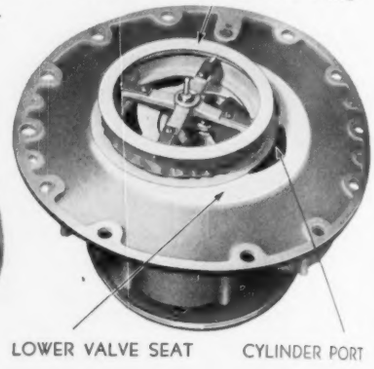


Fig. 23-41 DOUBLE FACED ROTATING VALVE



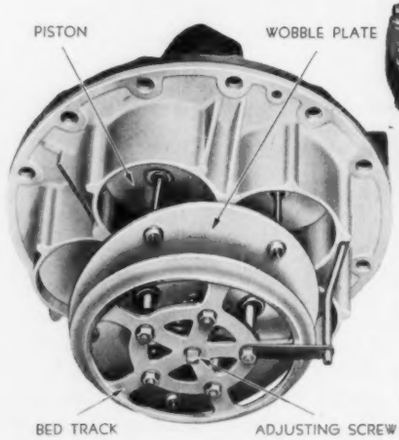


Fig. 23-42

Fig. 23-43

Fig. 23-44

Xacto meters are made for most liquids other than acids and water, in six pipe line sizes from ¾″ to 3″; maximum capacities 10 to 250 g.p.m.; weights of cast iron meters 21 to 225 lb (3 largest sizes also made in aluminum); diameters 7″ to 23″. Various styles of registers are furnished, as well as filling devices. Fig. 23-43 shows a package filling outfit (pre-determined quantity) with automatic discharge control. Fig. 23-44 shows one of the models provided with an adjusting dial whereby, in connection with charts furnished by the manufacturer, the meter can register the quantity of liquids of various gravities, at various temperatures, reduced to whatever basis has been specified. The registration curve (judging from actual test records) is practically flat from 1% to 100% of rated capacity, the greatest deviations occurring, oddly enough, at around 10%. The deviations are proportional to the working

†This is only approximately true of a meter with an odd number of cylinders but it gives the idea.—M.F.B.

pressure and represent errors of 0.10% at 15 lb per sq. in., 0.12% at 30 lb and 0.14% at 50 lb. in the cases the author investigated. At extremely low rates of flow the condition of the individual meter seems to be the main factor, judging from the wide diversity of dribble test results. This characteristic is to be expected by reason of the use of plunger leathers and other construction details; but a limit of error of 0.3% seems attainable at all flow rates above 1% of capacity. Pressure loss curves show that the 1½" meter requires a 12 ft. head of gasoline (0.77 gravity) for capacity flow of 50 g.p.m.; the 2" meter 25 ft. for 110 g.p.m.; the 2½" meter 19 ft. for 180 g.p.m. and the 3" meter 30 ft. for 250 g.p.m. (Note—1 ft. of liquid of 0.77 gravity at 60° F. = 0.333 lb per sq. in.)

(d) Oscillating and Rotary Piston Types

In these types the piston does not reciprocate but executes a pre-determined motion in the course of which it uncovers an inlet port, displaces a fixed quantity of liquid and isolates it, uncovers an outlet port and discharges through it. The moving element thus performs the functions of a piston and of a valve, but not that of a velocity-impelled element as does the rotor of a current meter. These meters, therefore, in spite of the inability of most of them to pass a rigorous dribble test, are positive displacement meters. Any of the oscillating piston meters named below, if it be in good condition, will show as straight a registration curve *within its operating range* as would some of the reciprocating piston types discussed above.

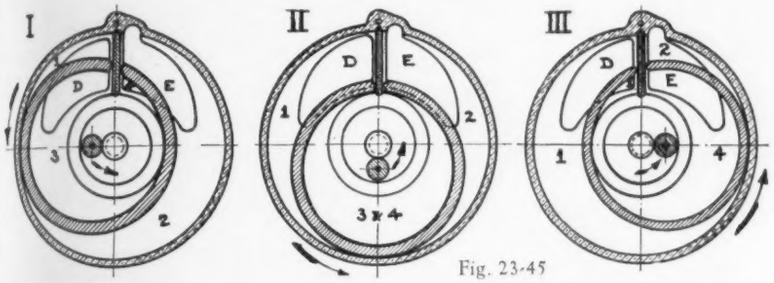


Fig. 23-45

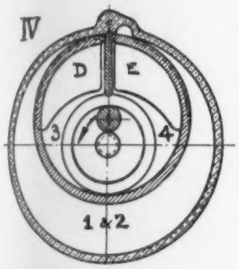


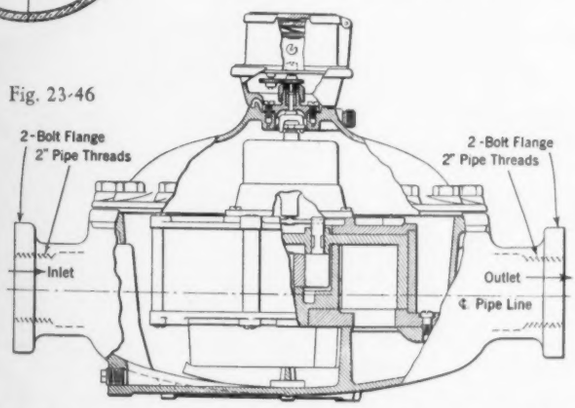
Fig. I. Spaces 1 and 3 are receiving liquid from inlet port, D, and spaces 2 and 4 are discharging through outlet port E.

Fig. II. The piston has advanced and space 1, in connection with the inlet port, has enlarged and space 2, in connection with the outlet port, has decreased, while spaces 3 and 4, which have combined, are about to move into position to discharge through the outlet port.

Fig. III. Space 1 is still admitting liquid from the inlet port and space 3 is just opening up again to the inlet port, while spaces 2 and 4 are discharging.

Fig. IV. Liquid is being received into space 3 and discharged from space 4, while spaces 1 and 2 have combined and are about to begin discharging as piston moves forward again to occupy position shown in I.

Fig. 23-46



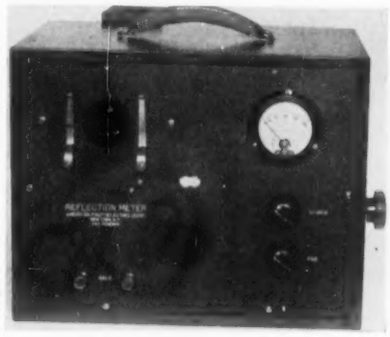
The "*Empire*" (National Meter Co.) was brought out in 1884 as a water meter but has been developed for all liquid petroleum products, ammonia, beverages, inks, syrups, tar, varnish and numerous other liquids. All sizes and models, however, are characterized by the same ring-shaped piston and employ the same principle, illustrated in Fig. 23-45 and described in the caption. It is regularly made in eight sizes for oil (½" to 6") and in eight sizes for water (⅜" to 6"). The corresponding rated capacities are, for oil, 10 to 500 g.p.m.; for water, 20 to 900 g.p.m. The operating ranges start at 2½% of rated flow and extend beyond 100%, many Empire meters being run at 100% overload for long periods in the oil industry, for example.

Photoelectric Reflection Meter

American Photoelectric Corp.

TO compare and measure the total reflection factors of similar opaque materials, this new instrument illuminates an area of approximately 3 sq. in. of the material under test, measures on a comparative basis the total illumination reflected from this area of the material. The comparison standard may be another similar sample, the surface of a block of magnesium carbonate, or any other desirable standard.

This instrument is intended for operation on 110-120 volt current, either a.c. or d.c., but it may be furnished for operation on other voltages if desired.



No additional batteries or sources of power are required. Circuit stability is maintained even with small variations in line voltage supply. A rheostat and line voltage meter are provided to keep the voltage approximately at the same value for all measurements.

The majority of working parts are mounted on the Bakelite front panel, and the whole is enclosed in a natural-finish polished mahogany case.

Reflection—The sample is "viewed" by two photocells placed at an angle of 30° from the illuminated surface. The combined output from these photocells is applied to a galvanometer, and balanced by the steady output of a third photocell, applied to the galvanometer through a slide wire bridge contained within the instrument.

For comparing reflection factors of two similar samples, the lighter of the samples is placed in the sample holder and, with the slide wire set at 100, the galvanometer is connected and the slide wire adjusted until the galvanometer again reads zero. The sample to be compared is then placed in the holder in the same manner, and the slide wire adjusted until the galvanometer again reads zero. The reading of the slide wire then indicates the percentage of reflection from the second sample based on the first as 100%.

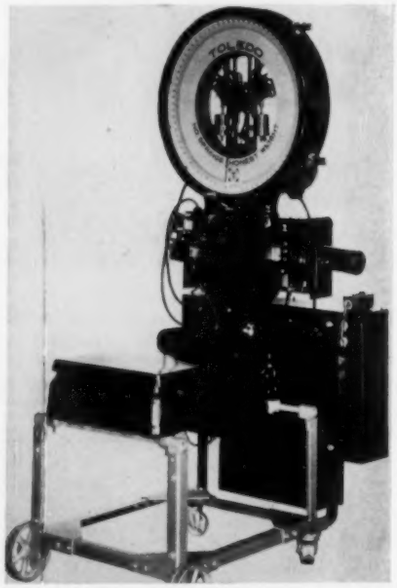
If measurements of reflection on the basis of a standard white are desired, the instrument may first be calibrated to 100% with a block of magnesium carbonate or other suitable standard, and the absolute reflection factors of various samples determined independently of one another.

The scale of the slide wire used is graduated to 0.5% and readings may be estimated to 0.1%. The methods of determining *opacities* and *translucencies* by the use of the APC Reflection Meter are likewise rapid, accurate and reproducible.

Tare Packaging Auto-Gage

Toledo Precision Devices, Inc.

DIFFICULTIES in packaging arising from variation in weight of the containers used have been overcome by this new device suitable for the packaging of all semi-solid and liquid materials similar in composition. For instance, it has reduced the whole export lard packaging process to a push-button operation, so that one man can operate several machines efficiently and without fatigue. Adjustments are automatically made for any variation in the weight of the containers being used. This device is a Toledo Auto-Gage equipped with a photo-electric tube and with an automatic tare device consisting of an electrically driven screw poise and tare balancer.



The rear dial has 3 indicators: One for the tare adjustment, one for the weight of one compartment of the lard box and the third for the weight of the second compartment of the box. The tare indicator is set at zero and the other two at their respective weights. When an empty container is placed on the auto-gage, the operator pushes a button; the tare device automatically adjusts the indicator to zero. As soon as the tare indicator reaches zero, the photo-electric tube releases the feed valve and one compartment is filled. When this is completed, the second valve opens and fills the second compartment. These valves are equipped with a slow feed so that when the desired weight is nearly reached, the flow of material is retarded. Hence, no waste from overflow. When one container is filled, the device cannot operate again until the box is removed from the platform. In addition, there is a stop switch enabling the operator to stop the operation in case of emergency.

This auto-gage can be furnished with the automatic tare attachment alone and the packaging operations can be done by hand. In place of four automatic feed valves, one or more can be furnished according to the desired work.

The *"Red Seal"* (Neptune Meter Co.) employs a ring-like oscillating piston, and Fig. 23-45 may serve to illustrate its operation, though, of course, it is not a copy of the previously-described meter. It is made for oil and gasoline in three sizes: 1½", 2" and 3", with capacities of 65, 100 and 200 g.p.m. Fig. 23-46 shows a section of the 2" meter. The "accuracy curves" in the makers' literature do not extend below 10% of rated flow; but typical registration curves drop below 98.5% (1.5% "slow") at 4.5% of rated flow for the 2" size and at 7.5% of rated flow for the 1½" size. In other words these meters are accurate at fairly low rates of flow.

Radically different from the foregoing in both exterior and interior appearance, the *Granberg Petroleum Meter* (Granberg Meter Corp.) nevertheless belongs to the oscillating piston type, although its displacement elements are termed "valve" and "valve guide." Extracts from the makers' description:

The four diagrams, Fig. 23-47, show the position of the valve and valve guide at four different points during an operating cycle. Bearing in mind that the crank pin fits into the hole in the center of the valve, and that the valve as such does not revolve, it can be understood that any point on the valve travels on a circle of the same diameter as that described by the crank pin, but on an independent center of its own. Hence each of the four ports in the bottom of the valve travels in a circle as does the crank pin, but inasmuch as their centers are set at approximately a distance off the

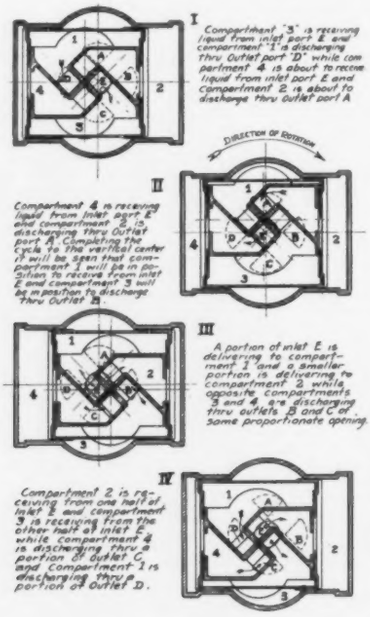
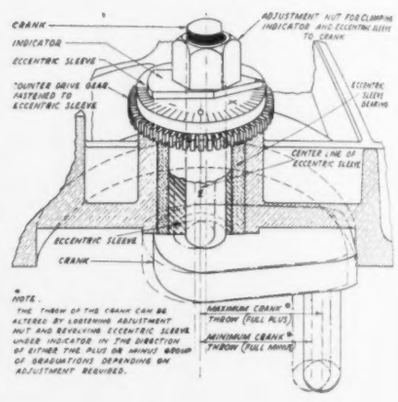

I
Compartment "3" is receiving liquid from inlet port E and compartment "1" is discharging thru outlet port "D" while compartment 4 is about to receive liquid from inlet port E and compartment 2 is about to discharge thru outlet port A
DIRECTION OF ROTATION
II
Compartment 4 is receiving liquid from inlet port E and compartment 2 is discharging thru outlet port A. Completing the cycle to the vertical center it will be seen that compartment 1 will be in position to receive from inlet E and compartment 3 will be in position to discharge thru Outlet B
III
A portion of inlet E is delivering to compartment 1 and a smaller portion is delivering to compartment 2 while opposite compartments 3 and 4 are discharging thru outlets B and C at some proportionate opening.
IV
Compartment 2 is receiving from one half of inlet E and compartment 3 is receiving from the other half of inlet E while compartment 4 is discharging thru a portion of outlet C and compartment 1 is discharging thru a portion of outlet D.

Fig. 23-47

Fig. 23-48


CRANK
INDICATOR
ECCENTRIC SLEEVE
COUNTER DRIVE GEAR FASTENED TO ECCENTRIC SLEEVE
ADJUSTMENT NUT FOR CLAMPING INDICATOR AND ECCENTRIC SLEEVE TO CRANK
ECCENTRIC SLEEVE BEARING
CENTER LINE OF ECCENTRIC SLEEVE
ECCENTRIC SLEEVE
CRANK
NOTE:
THE THROW OF THE CRANK CAN BE ALTERED BY LOOSENING ADJUSTMENT NUT AND REVOLVING ECCENTRIC SLEEVE UNDER INDICATOR IN THE DIRECTION OF EITHER THE PLUS OR MINUS GROUP OF GRADUATIONS DEPENDING ON ADJUSTMENT REQUIRED.
MAXIMUM CRANK THROW (FULL PLUS)
MINIMUM CRANK THROW (FULL MINUS)

center of the valve equal to the radius of the crank pin circle, the path of their travel is such that at one point they are over the inlet port which is under the center of the crankshaft. If the location of the four outlet ports in the base plate surrounding the inlet port is noted, it can be seen that the circular path of each valve port as above described includes only one of these outlet ports. It therefore follows that each valve port communicates alternately with an inlet and an outlet port, but never with both at the same time.

Except for momentary intervals when the valve or valve guide are at the ends of their strokes, two compartments are always receiving liquid and two compartments are discharging liquid, each at varying rates, dependent upon the position of the crank pin. However, the sum of the two volumes being discharged or received is always the same, and this results in a uniform flow through the meter without pulsation.

Adjustment Features: Adjustment is accomplished by altering the throw, or effective radius, of the crank by means of an eccentric sleeve which fits over the stem of the crank shaft. This changes the amount of movement of the valve and valve guide and hence the displacement per revolution. See Fig. 23-48.

The Granberg meter is regularly made up in three "types" and four sizes—a total of nine different regular models, with capacities of 3 to 25 g.p.m. for the "C-1"" to 50 to 350 g.p.m. for the "F-3"." There are light, heavy and extra-heavy case models. The range of adjustment is between 3% and 4%, plus or minus. Each size of each "type" has two maximum working pressures, one for "slow closing valve" and one for "fast closing valve." The makers publish for every one of their four sizes "accuracy" (registration) curves and pressure-loss curves for both gasoline and heavy oils. The registration curves give more data than those printed in the general-circulation literature pertaining to any other liquid displacement meter. Also worthy of mention is a 64-page booklet of instructions for installation, operation and repair.

Direct-reading Meter for Power and Impedance Measurements

General Radio Co.

IT has heretofore been necessary, when power measurements were to be made over a wide range of impedance values, to use a decade resistance box and a meter to indicate current or voltage. This is a laborious process. An instrument which indicates directly power and impedance enables these measurements to be made simply and conveniently. The Type 583-A Output Power Meter, designed for this purpose, consists of a variable ratio transformer, a loss adjusting network to give constant loss at all ratios, a meter multiplier network, and a copper-oxide rectifier-type meter.

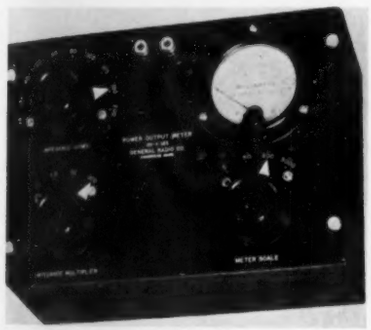
The impedance range is extremely wide, extending from 2.5 to 20,000 ohms. This ratio of 8000:1 covers all the impedance values likely to be encountered in communication measurements.

The ratio of maximum to minimum power which can be read on the meter is 50,000:1, extending from 0.1 milliwatt to 5 watts. An auxiliary scale in decibels referred to a zero level of one milliwatt is also included.

The input impedance of the instrument is adjustable in 40 steps spaced at approximately logarithmic intervals. This feature is of considerable importance. With logarithmic steps of impedance, therefore, the impedance corresponding to maximum power output can be closely estimated as the impedance switch is varied.

The scale for power calibration follows an inverse square law. This spreads out the low end of the scale allowing the meter to be read closely at low scale deflections.

Although the impedance can be varied by a ratio of 8000:1, the error in full-



scale power reading does not exceed 0.3 db between 150 and 2500 cycles and the average error between 30 and 5000 cycles is also not greater than 0.3 db. Between 20 and 10,000 cycles the average error is 0.6 db and the maximum error at any impedance setting at these extreme frequencies is 1.5 db.

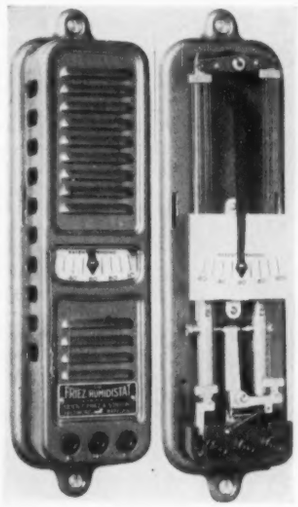
The impedance error is also quite small over the greater portion of the frequency range. Between 150 and 3000 cycles this error does not exceed 7%. The average error between 30 and 5000 cycles is 8%. Since the accuracy of the best copper-oxide indicating element is only about 4%, these figures show that the other circuit elements are held to extremely small tolerances. At higher and lower frequencies, as might be expected, the impedance error increases.

New Humidistat

Julien P. Friez & Sons, Inc.

THIS automatic control instrument for air conditioning is claimed to have extreme accuracy coupled with very low price. The hygroscopic element used is of human hair, which is selected, treated, mounted and calibrated exactly as are the elements in expensive Hygrothermographs used by practically all U. S. Government services.

Human hair elements, scientifically treated, have proved themselves free from appreciable shift of calibration and much more sensitive than other hygroscopic elements. They have the added advantage of effective operation up to the saturation point, a virtue not possible where wood or paper elements are used. Friez hair element can be easily cleaned of dust or oil deposit, remain in good working order indefinitely, and are unaffected by temperatures up to 175° F. The element consists of 54 selected human hairs, each individually mounted and ventilated. Double length element is provided by operation through a pivoting bridge and the overall dimensions are thus kept compact.



The mounting of the sensitive mechanism is entirely independent of any twisting of the case that might result where the instrument is fixed to unevenly surfaced walls, etc.

The Humidistat is ordinarily used as a 3-wire instrument in conjunction with suitable relay, thus insuring absence of chatter, but may also be used to make a pair of contacts at desired low or high humidity. All wiring connections are made from outside without removing the case. The instrument contacts will carry up to 25 watts at voltages up to 110 v.

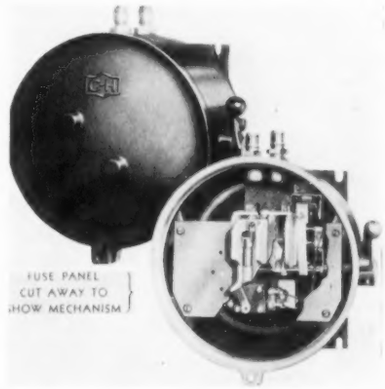
As ordinarily sent out the instrument is adjusted for minimum differential, approximately 1% relative humidity. Adjustment can be made, however, to increase this differential to any wider range desired. A pointer is provided for setting at the desired relative humidity, between 20% and 100%.

The cases are ordinarily turned out in an attractive old gold cellulose but can be finished in any way desired.

Explosion-Proof Manual Control Starters

Cutler-Hammer, Inc.

A NEW, air-break type of d.c. explosion-proof, across-the-line, manual control, approved and rated "permissible" by the U. S. Bureau of Mines, is announced. These 2-pole starters have thermal overload and low-voltage protection and are rated 4 h.p. at 230 volts, and 5 h.p. at 550 volts. A main line fuse is built into the cast-iron case which has a screwed-on cover. The overload when tripped is reset by the outside operating lever.



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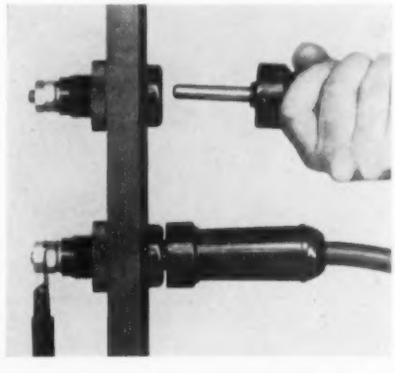
Laboratory Plug Switches

General Electric Co.

THREE sizes of new laboratory plug switches, 100, 50 and 25 amps., cover a range suitable for practically all laboratory requirements. They are designed for use on low-voltage circuits and, while not primarily expected to make or break current, have been designed to withstand such treatment with minimum injury. The receptacle of the 100-amp. switch has a Textolite bushing mounted on the panel, and a split jaw in it with necessary nuts and washers. The plug, likewise, consists of a Textolite handle and of a slightly tapered brass bayonet. The 50-amp. and 25-amp. switches have a different construction which also conserves space. The brass receptacle is solid at the threaded end, while the flanged end is drilled and slotted on one side of the hole only. The plug handle is of horn fiber, tapped at one end, into which the bayonet is screwed. The insulating collar of the receptacle is also of horn fiber, giving the board on which the unit is installed a dead-front effect. Simplicity and strength characterize all 3 sizes.



Inexpensive Noise-Measuring Equipment

General Radio Co.

MANUFACTURERS of mechanical equipment are beginning to recognize the importance of quietness in their products. Listening tests are of no substantial value. The simplest form of noise-measuring set-up consists of a microphone, an amplifier, and a suitable indicator. Sounds picked up by the microphone are amplified and indicated on the meter, giving a definite method of comparison. The meter should preferably be calibrated in decibels. Where wide ranges of volume are to be measured, the amplifier gain should be adjustable to avoid overloading on loud noises.

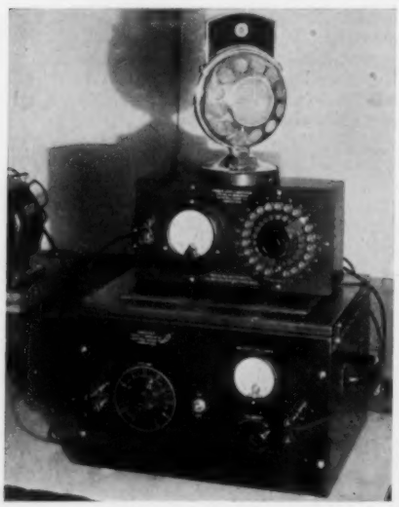
In order to present a true picture of the effect of the noise on the human nervous system, the measuring system must have a frequency characteristic similar to that of the normal auditory system, i.e., the low and high frequencies must be discriminated against.

Since a flat frequency characteristic is not desired, an expensive microphone is not generally needed unless very low noise levels are to be encountered. The microphone should, however, show negligible variations with use and age and should have a residual noise level substantially below the lowest noise to be measured. The input transformer or frequency-weighting network should be so designed that its characteristic added to that of the microphone results in a close approximation to the normal ear characteristic.

A noise-measuring set of this type may be composed of several standard General Radio units. The system illustrated consists of a General Radio Type 514-AM Amplifier, a special Type 345-SN Input Transformer, a Type 586-CM Power-Level Indicator, and a microphone. The input transformer matches the microphone impedance to the amplifier and also adjusts the over-all frequency response to approximate that of the human ear. In this particular system, the input transformer is mounted in the amplifier cabinet, and the microphone receives its current from the amplifier filament battery.

The microphone is an inexpensive carbon type, since the noise levels at which it is to be used are comparatively high. The over-all response of the complete system, including microphone, represents a very close approximation to the response of the normal human ear.

If desired, the special input transformer may be mounted within the amplifier unit and the amplifier input circuit arranged so that microphone current is obtained from the amplifier "A" battery.



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Throttling and Three-way Motorized Valves

Barber-Colman Co.

1. THROTTLING VALVES

THESE small electric-motor-operated throttling valves have been designed for service where conditions require graduated valve action. They are especially useful on small blast systems and air conditioning systems where throttling valves smaller than the 2" size are required. These valves are available in packed or packless models, high-pressure or low-pressure types, in sizes from ½" to 2". The motor-operator used is a small size Barber-Colman Reversing Damper Controller mounted on a special bonnet fitted to the same type of body, disk, plunger, and packing gland assembly as is used for corresponding positive acting valves. Since a "reversing" type operator is used, it can be stopped, restarted in the same direction, or reversed at any position between the points where the valve is fully open or fully closed. The speed is conveniently adjustable after installation. Auxiliary "training" switches are incorporated in the motor-operator and from these switches it is possible to actuate other apparatus such as the subsequent valves on a blast system.

2. THREE-WAY VALVES

ARRANGED to be opened and closed by an electric motor-operator unit mounted in place of the customary handwheel, these valves are of the conventional 3-way type and are available in sizes from ½" to 2" with either positive or reversing operators as required. The positive operator is for use in installations requiring a complete change-over from one to the other of the 2 paths through the valve. The reversing operator is for use in mixing service where the 2 inlets are to be partially opened as required to give throttling action.

The motor-operator consists of a "Barcol Midget" shaded pole induction motor which, by means of a train of reduction gears, turns a cam and consequently moves the valve plunger up or down to place the double faced disk against either of the 2 seats or to position it properly between them as required. The valves may be controlled from a manual or automatic switch or from a suitable thermostat. Power required is 25-volt 60-cycle a.c.

Protective Cases for Watthour Meters

General Electric Co.

AN aluminum-alloy die-cast case for the protection of single-phase watthour meters of modern construction has been announced. It is strong, durable and corrosion-proof, and protects the meter against most adverse weather conditions. In addition, access to the meter is impossible without leaving positive evidence, either by breaking the seal or by damaging the case itself. Its modernistic shape presents an attractive appearance. Water cannot enter between the meter cover and box cover, a thick rubber gasket under compression being employed there. Should water seep in between the cover and the box, it will not run down the conduit but will pass out of the case through drain holes.

Close-up of new protective case, and appearance installed outdoors on a dwelling.

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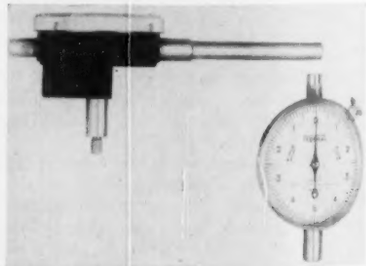
"Tenths" Dial Indicator

Federal Products Corp.

KNOWN as Model 82, this new dial indicator has the spindle operating through the center of the back instead of through the side of the case. This is probably the first time that this construction has been adopted for an

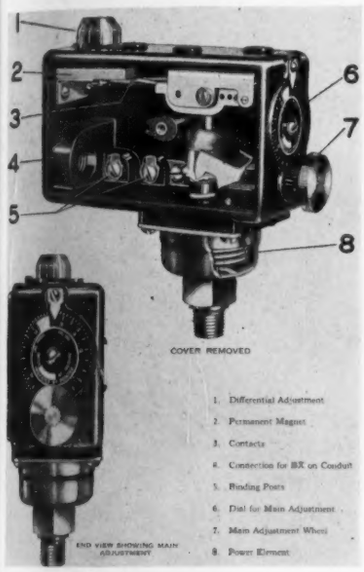


indicator graduated in 0.0001 in. divisions. The new instrument has a range of 0.020 and the dial can be furnished with calibrations of either 0-50 or 0-10. Either a jeweled bearing or a plain bearing movement can be furnished.

Temperature and Pressure Control Switches

Detroit Lubricator Co.

FURNISHED in various models for the control of temperature, pressure or vacuum, the new No. 250 "Genuine Detroit" control switch comprises a bellows element (actuated by the pressure to be regulated, or by a volatile liquid for temperature) which element operates the mechanism to open or close the circuit. A permanent magnet at the contacts provides quick make and break. The switch carries full line current 110 or 220 volts a.c. or d.c. as for example, at 110 volts a.c., repulsion induction motors up to 1 h.p. Both the operating range and the differential are adjustable. Changing the differential does not alter the point at which the circuit closes. Changing the range setting does not change the differential but raises or lowers both points.



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Meter Measures Current Without Being in Circuit

Columbia Electric Mfg. Co.

TO measure current in cables or other conductors without interrupting the circuit, the "Tong-Test" instrument employs the induction principle. Of the split electromagnet type, it has no electrical windings, and therefore cannot burn out or short-circuit, and it may be operated by one hand. The two-part laminated magnet yoke is opened by pressing the trigger; the jaws are passed around the conductor; the trigger is released; and the reading taken. The jaw-opening will accommodate cables up to 1⅝" diameter. The total weight of the instrument is only 2¼ lbs. No connection to the circuit is required, the magnetic flux of the current in the cable being used to operate the meter.

Readings may be taken of both d. c. and a. c. with the same instrument—even on d. c. circuits in which the cable is of the single cored armored type, or if the wire is run in steel conduit. Interchangeable elements give ranges of 50, 100, 150, 200 and 400 amps. The instrument is low-

priced, requires no shunts or ratio transformers; and gives long accurate service under the trying conditions of maintenance work.

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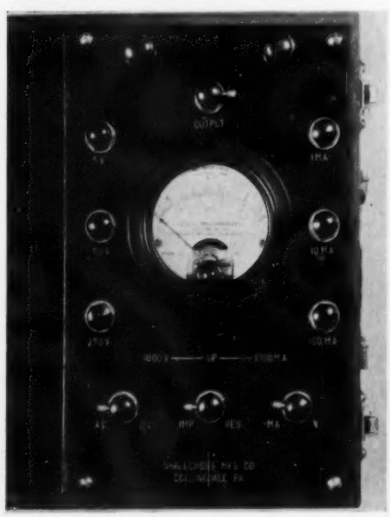
General Purpose Meter

Shallcross Mfg. Co.

EVERY technician interested in the design and construction of apparatus employing electronic tubes will find a general purpose meter of great value in the laboratory. This new instrument is designed for such service. It provides a wide range of measurements as follows:

D.-c. Voltage ranges....5-50-250-1000 volts
D.-c. Current ranges....1-10-100-1000 m.a.
A.-c. Voltage ranges....5-50-250-1000 volts
Resistance (d.c.) ranges.....
.....100-1000-10,000 ohms
Resistance (a.c.-imp.) ranges.....
.....10,000-100,000-3,000,000 ohms
Inductance (a.c.-imp.) ranges.....
.....1 to 100-1000-10,000 Henrys
Capacitance (a.c.-imp.) ranges.....
..... .001 to 0.1-1.0-10 mfd.
Output Meter (approx. 5,000 ohms).....
.....5-50-250 volts a.c.

Resistance, impedance, inductance and capacity determinations are made by reference to easily-read curves supplied by the company.



Room Temperature Control

Detroit Lubricator Co.

DIFFERING in several respects from the usual types of room thermostats, the new "Genuine Detroit" Temperature Regulator comprises a thermal motor unit of simple design and rugged construction. A low-voltage low-temperature electric heating element is immersed in a chamber containing a volatile liquid. When the wall thermostat makes circuit to the heating element, the resultant increased pressure is exerted through a connecting tube to the bellows chamber of the motor unit which consequently operates the furnace damper. The makers assert that this control system is noiseless in operation, has ample power to operate dampers, can be installed without a licensed electrician and requires no attention after installation.

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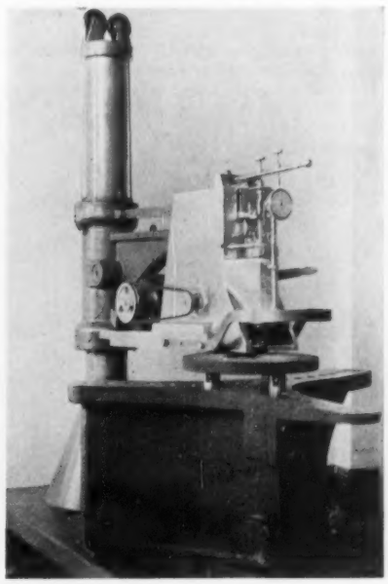
Grinding Wheel Grader

Abrasive Engineering Corp.

DEFINITE limits of grinding wheel tolerance for every grinding operation promote economical production of high-standard products, but only if they are maintained by accurate hardness measurements of the wheels. Substituting quantitative determinations for methods involving personal factors, the Grade-O-Meter mechanically lifts a ram of known weight, carrying a contact point of known area, to a certain height and permits it to fall a given number of times on a localized area of the grinding wheel or other substance being tested. Between each impact the contact point of the ram is revolved a fraction of a revolution, while out of contact.

This produces a round hole in the substance being graded. The rectangular contact point of the ram does not fit the round hole; hence the only resistance to its penetration is the strength or structural tenacity of the substance being graded. The extent of this resistance is a function of the depth of the hole produced by a given number of impacts, and this is accurately indicated by a properly graduated dial indicator. This test does not spoil the grinding wheel.



Novel Instrument Tests Milk Curd Consistency

The Heusser Instrument Co.

UNTIL Dr. R. L. Hill evolved what has come to be known as the Hill Curd Test, the general notion prevailed that all milk was more or less alike. He revealed that even milk from the same strain of cows or goats differs greatly in curd consistency or tension. (Fat content and other such characteristics do not point to difference in curd tension.) Curd consistency is an important index to the digestibility of milk and also its usefulness for other purposes.

The American Curd-O-Meter was designed for making this milk test. With it, a large number of samples can be tested accurately in a short time: a dozen samples in less than 5 minutes. The instrument combines a circular-veined curd knife with a sensitive spring balance. This curd knife is pushed down in the jar of milk sample, previously coagulated, and the tension of the curd is registered on a numerically graduated scale at the top of the instrument. A depth gage shows how far to push the curd knife down in the jar of milk. An automatic stop keeps the graduated scale at the specific hardness of the test sample until released, so reading can be taken after instrument has been removed from jar. The housing and shaft are of duralumin. Curd knife and spring balance parts are substantially gold-plated.

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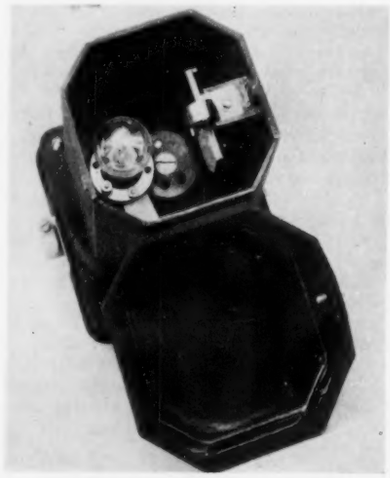
Compact Photoelectric Cell Outfit

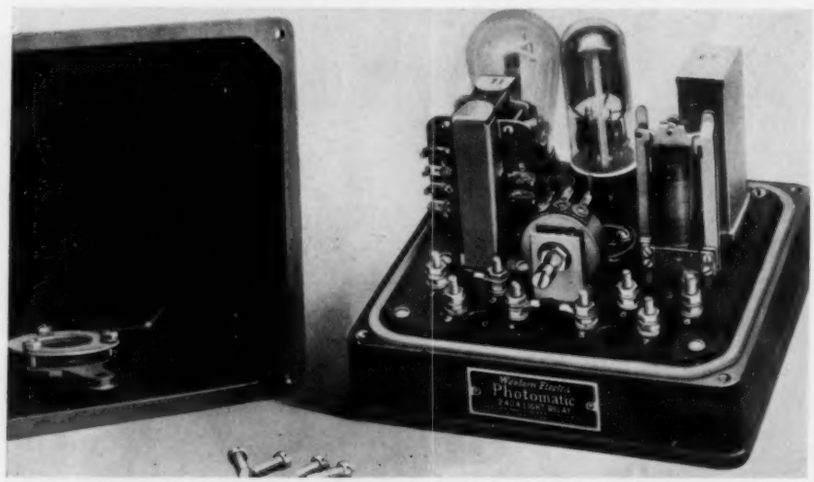
Western Electric Co.

DESIGNED by Bell Telephone Laboratories, a simple and compact photo-electric cell outfit, the "Photomatic Equipment," consists of two small units—one the light source and the other a light-relay which contains the photo-electric cell. Both are designed to operate from commercial 50-60 cycle, 115 volt a.c. mains. The equipment may be arranged to open or to close circuit on either the interruption or completion of the light beam.

The light unit, 5⅛" square at the base and 8⅝" high, contains an automobile headlight bulb fed by a suitable transformer, and a condensing lens to produce a parallel beam. The distance between the light unit and the light-sensitive relay may range up to 25 feet, but by using a 50 c.p. lamp it can be increased to 35 feet. The photo-electric cell can be actuated by a beam of light reflected by one or more mirrors. A light filter may be used if desired to render the beam invisible. This reduces the distance approximately 50 percent.

The light relay unit, 7" square at the base and approx. 6¾" high, contains the photo-electric cell, an amplifying vacuum tube, a relay and associated apparatus. The cast aluminum housing has a 1 1/16" window to admit light to the cell. Additional aperature plates are provided with ¾", ⅝" and 3/16" circular openings so that the amount of light admitted can be varied to meet different operating conditions. The caesium photo-electric cell is of the vacuum rather than the gas-filled type, to afford freedom from the possibility of injury by any illumination which can be given it by the light unit.





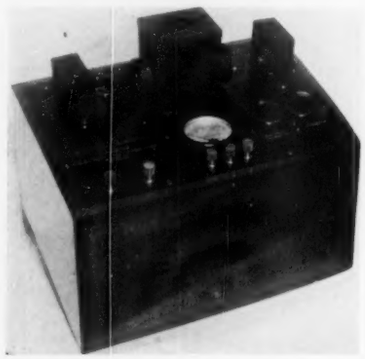
Photoelectric Color Comparator and Turbidity Meter

American Photoelectric Corp.

DESIGNED to compare and measure the total light transmission of similar colored liquids with a sensitivity greatly exceeding that of visual comparison, this new instrument operates as a Wheatstone bridge, two arms of which are photoelectric cells and two of which are adjustable resistances. The light source is a 100 watt type T-8½ Mazda projection lamp, enclosed in a suitable housing, and the current supply is 110-120 volts, either a.c. or d.c.

Small variations in line voltage affect the light falling on both photocells simultaneously, and do not disturb the stability of the instrument. A line voltmeter and suitable rheostat are provided, however, to keep the lamp supply voltage constant for all readings. Connections for a galvanometer and for a slide wire bridge are brought to binding posts on the panel.

For color comparison, the APC Advanced Model Color Comparator may be used in either of two ways. With the panel switch thrown to the side marked



"Comparator," a sample of the standard solution in a standard glass container is placed in front of the left photocell and the galvanometer adjusted to zero by means of coarse and fine adjustment knobs. The sample to be compared is now placed, in a similar container, in front of the same photocell and if the galvanometer again reads zero, the total transmission of light through the two samples is the same.

A more delicate comparison of two samples may be had by placing one in front of each photocell with the panel switch thrown to the "Colorimeter" side, and adjusting the galvanometer to zero. If the samples are interchanged, with everything else remaining constant, the effect of any differences is doubled, and precise matches may be obtained.

If the colors of two samples differ slightly, the degree of this difference may be read on the slide wire by a slightly different method: its scale will indicate the percentage difference in transmission between the samples under test, in terms of the lighter sample as 100%.

The attainable sensitivity is 0.05%, whereas the limit of eye sensitivity in a visual match is generally about 2%.

This new instrument has also been made adaptable for the direct measurement of turbidities in the study of suspensions, colloids, etc., and for sulphate and similar determinations by the Tyndall beam method.

Precision Boring Machine Combined with 3-Coördinate Measuring Machine

R. Y. Ferner Co.

IN their latest machine, the Société Genevoise d'Instruments de Physique of Geneva, Switzerland, have combined the unusual possibilities of making accurate measurements in 3 coördinates with unique features in a precision boring machine. The gear box provides 6 spindle speeds, from 190 to 3000 r.p.m., making it possible to drill holes as small as 3/64" or as large as ½" in steel, while boring can be carried to 1.6". The spindle will run at 3000 r.p.m. for an indefinite time without heating in spite of the total absence of play in the bearings. The most unusual feature of the machine is that the work table rests directly on the ways in the

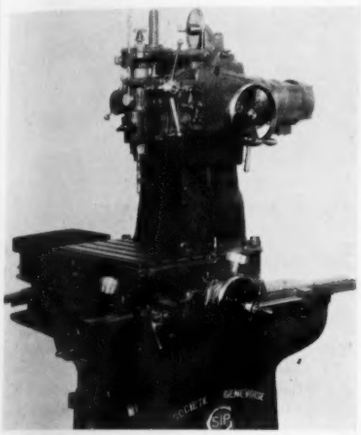


Fig. 1

pedestal and can be moved in either coördinate. The bed ways are flat, very wide and far apart. The underside of the work table also has wide flat ways which are very long and lie *across* the other ways. The screws for moving the table along and across the bed ways are heat treated, have a special form of thread

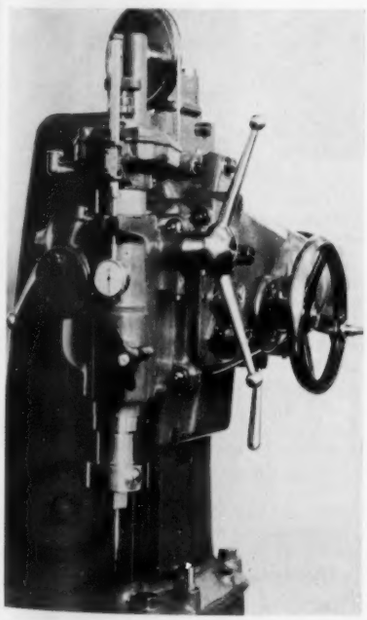


Fig. 2

cut with high precision, and are used for measuring, being fitted with micrometer heads reading by vernier to 0.00005" and provided with compensating templets having curves representing the magnified curve of the slight errors of the screws, whereby the vernier indexes are automatically adjusted. The makers guarantee that the maximum error of distances between finished holes will not exceed 0.00015". Complete stability of the work table, with no overhang in any position, eliminates the effect of wear and necessity for adjustment in the usual dovetailed ways of crossed tables.

Accessories. (1) A circular table 11.8" in diameter for measurements or boring in polar coördinates. Its micrometer head reads to 5 seconds of arc.

(2) A centering dial indicator device, to fit in the spindle of the boring head, used for lining up the job or for setting a central hole, or other hole already bored, beneath the spindle, or for measuring accurately the distance between any holes or between the edge of the work and a hole.

(3) A locating microscope and a reference square. A reticle of crossed lines seen in the field of view of the eyepiece corresponds, in its position, to the axis of the spindle. The reference square has a line on its upper surface lying in the plane of the inner surface of the other leg of the L-shaped piece, so that, in placing this over the edge of a job, a sight with the microscope on this line places the spindle exactly over the edge of the job. This method is used in measuring, for example, the distance between the jaws of a snap gage.

Other accessories are an automatic center punch device, a 3-jaw chuck for holding straight shanked tools, etc., etc.

For vertical measurements, and for measuring the depth of holes being bored, a vertical measuring attachment (Fig. 2) can be read to 0.001" by means of a vernier, and a dial indicator can be used in combination with the graduated scale for direct readings of vertical movements of the spindle or it can be used as a zero indicator; or, for a higher precision, a Jo block or similar gage can be placed between the graduated rod and the dial indicator to establish the vertical distance to be measured.

Other new features are, mounting of motor and gear box in the slide with the boring head, counterbalancing of this slide and of the guill and spindles separately by the same weight, etc.

As a precision laying-out, drilling and boring machine this equipment is particularly useful in the manufacture and measurement of parts of scientific instruments, timepieces, office machines, small motors or any parts up to about 10x15" requiring accurate holes or outlines.

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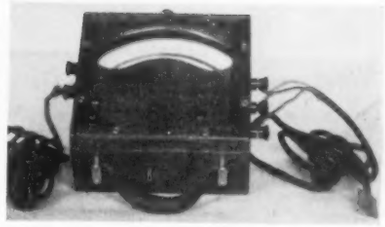
Bodily Temperature Indicators and Recorders

General Electric Co.

CONTINUOUS records of the temperature of a patient, a new means for determining the surface temperature of infected portions of the body, and a method for learning about the temperature differences of body terminal regions are made possible by a new instrument developed by the above company. The device, incorporating a resis-



tance thermometer and either an electric indicating or recording instrument, is more accurate for its purposes than previously used thermocouples and mercury thermometers, and it is less elaborate, without sacrifice of accuracy, than other equipment for making permanent and continuous records of bodily temperatures.

If a temperature determination of the skin at an infected region is required, the physician places the resistance element against the skin and reads the temperature direct on the scale of a portable meter connected to the usual 110-volt house supply. The resistance element in this case is a flat pad, about an inch square, containing a copper coil which is extremely sensitive to changes in temperature. For determining internal, or general body temperature the bulb is a small, cartridge-like unit.

The indicating meter can be read directly to a half degree F. and can be approximated to finer readings. For permanent records of temperature changes it is necessary only to substitute a recording instrument in place of the indicator. Such instruments are expected to be of particular value in medical research.

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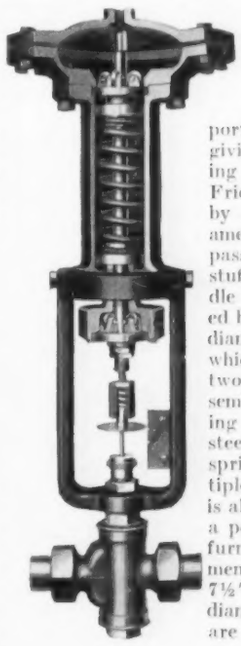
Improved Diaphragm Valves

C. J. Tagliabue Mfg. Co.

AFTER more than a year's industrial service, the TAG Friction-Free Diaphragm Valve was formally announced at the time of the Power Show. An improved super-structure is mounted on TAG "high-lift" V-port balanced valves, giving gradual opening characteristics. Friction is minimized by reducing the diameter of the spindle passing through the stuffing box. The spindle is perfectly guided by its upper (large diameter) portion which passes through two roller bearing assemblies, each consisting of four stainless steel rollers. The spring (single or multiple) is enclosed, as is also the diaphragm; a positive indicator is furnished; adjustments are easily made. 7½", 9½" and 11½" diameter diaphragms are available.

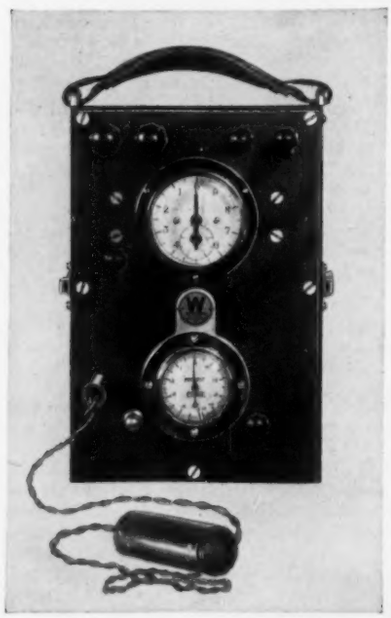


Stroboscopic Meter Standard

Westinghouse Electric & Mfg. Co.

MAKING meter testing as simple as setting a time piece, a new portable stroboscopic meter standard, which can be used for testing any make of meter, is claimed to bring laboratory accuracy into field testing.

In meter testing, the problem is to obtain an accurate comparison of two meter disk speeds, one disk speed being that of a standard meter and the other that of the meter under test. The new standard, offered as an effective means of solving this problem, weighs only about 15 lbs., and consists essentially of (1) a complete precision watthour meter for conventional meter testing and (2) stroboscopic equipment providing advantages entirely new in meter testing. The case enclosing it is divided into two compartments, one containing the precision meter complete with dials and pointers, an incandescent lamp to serve as a light



source, and a photo-tube, the other containing a power unit and amplifier connected to a neon lamp through a flexible cord.

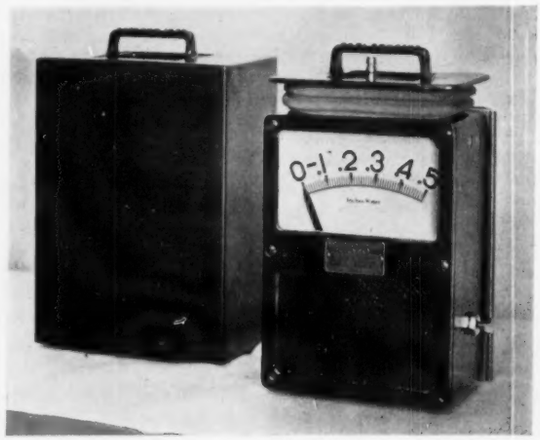
In use, the meter element is connected in series with the meter under test, both being connected to the same load. The incandescent lamp is lighted and the neon lamp placed near the disk of the meter being tested so that its light strikes the disk. Light from the incandescent lamp, interrupted by peripheral notches in the standard meter disk, strikes the photo-tube; the neon tube flashes in synchronism and the disk of the meter under test, observed in this intermittent light, appears stationary if it is in perfect synchronism with the standard meter. Thus to calibrate the meter it is necessary merely to adjust its speed until the disk appears to stand still.

In the illustration, the top dial is that of the standard meter, the bottom dial shows the percent error.

Dry Type Portable Draft Gages

The Hays Corp.

EMPLOYING the same slack leather diaphragm pressure-measuring units which have been embodied in the makers' panel-board draft gages, these new instruments are chiefly distinguished by being portable. They are, however, furnished also in a lug mounted style or in a flush mounting style. Among the listed features are the following: (1) Can be set up for service in 30 seconds. (2) Black lacquer finished cast aluminum case with glass window and slip-over metal cover. (3) Carrying handle. (4) Convenient reel for carrying rubber tubing without kinks. Clips for carrying metal tube which is inserted into smoke pipe to get draft reading. (5) Compact. Weight 4¾ lbs. Overall dimensions 5″ x 4″ x 9″. Scale length 3″. (6) Scale graduations in 1/100″ water. (7) Rugged and built for years of trouble-free service. (8) Zero setting takes only five seconds. (9) Does not require leveling. (10) The standard ranges are either ½″, 1″, 2″, or 5″ water.



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New Lovibond Tintometer

The Tintometer, Ltd.

DEFINING or specifying colors on a scientific basis has been made possible by various systems, one of which is the Lovibond. This re-designed apparatus is a complete colorimeter for use in laboratories and factories where the color of materials, either liquid or solid, has to be tested. It is compact and portable. The fields of vision are side by side. Neutral tint slides can be superimposed on the color field to render matching accurate.

The indicator is visible while making observations. The instrument can be used to determine the color of opaque substances as well as for transparent liquids or solids.

The Lovibond Color System depends upon the comparison of the color to be measured with permanent glass color slides of known absorption. These slides consist of three series embodying a red scale, a yellow scale and a blue scale, graded in varying depths of color, each slide having its numerical absorption value in the Lovibond Color Scale, these values being expressed in decimal notation, the minimum being .01.

The slides were established and are still graded for use in diffused daylight. The instrument is set up about 1 ft. from a North window which has been covered with Tintometer diffusing tissue paper.

If diffused daylight is not available, the whitest possible light approaching daylight should be used, but for comparative readings the source of light must be specified, and its distance from the instrument and from the sample and the angle at which the light falls on the sample must be stated. Sunlight must be avoided.

By suitable selection of the Tintometer slides, any color which lies between white = total reflection, or black = total absorption, can be accurately recorded.

Transparent substances, liquid or solid, are matched by transmitted light, the sample to be tested being placed in the cell holder, and then the knobs are moved from left to right until the two fields appear of equal color. The value of the slides used to make the match is read off the indicators.

Opaque substances are matched by reflected light, the sample to be tested being placed so that the light it reflects is visible in the left hand aperture and a tray of standard white powder is placed so that the white light it reffects is visible in the right hand aperture. The procedure for matching is then the same as for transparent substances.

The angle at which the light falls upon the sample and the angle at which the reflected light enters the instrument must be carefully standardized.

INSTRUMENTS ABSTRACTS

Abstracts on instruments and devices for measurement, inspection and control.

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Upon receipt of the abstracts they are checked against permanent files to avoid duplication and after being rewritten to conform to our style they are classified.

Oftentimes an abstract can fit under two or even more sections. In that case we decide who will be most interested in the article, and include it under that field of reader interest. It is our aim to so arrange the abstracts that a person interested, for example, in viscosity, will keep in touch with all the important articles in his field if he reads only section 2.10. For instance, an article on "Vacuum Tube Means of Measuring Viscosity" appears under 2.10—under "Measurement and Control of Physical Properties—viscosity," although it would also fit under section (5.4)—"Electronic Devices and their Applications."

CLASSIFICATIONS
(By Fields of Reader Interest)

MEASUREMENT TECHNOLOGY (1)

This section includes all matters concerning the art and science of measurement as follows:

Measurement Theory (1.1)
Under this heading will be included: definitions, precision of measurements, systems of units, and dimensional analysis.

Measurement Practice (1.2)
Covers Calibration and Standardization.

Calculation (1.3)
This does not include computation for instrument design, but covers calculations as a mode of measurement.

MEASUREMENT and CONTROL (2)

This section is devoted to those general measurement practices and control applications that are not confined to any one industry or branch of engineering. Thus temperature measurement and control, being of as much importance in chemical as in metallurgical processes, is a general field of interest to all industries and all branches of engineering.

Length, Angle, and Area, Including Surveying (2.01)
Time, Speed, and Acceleration (2.02)
Weight, Density, and Specific Gravity (2.03)
Pressure and Vacuum (2.04)
Flow and Volume (2.05)
Temperature (2.06)
Heat and Combustion (2.07)
Humidity and Moisture (2.08)
Power, Work, and Output (2.09)
Physical Properties, (Viscosity, hardness, elasticity, plasticity, surface tension, etc.) (2.10)
Liquid Level (2.11)

TESTING and INSPECTION (3)

Physical Testing and Inspection (including strength tests, bending, magnetic analysis, X-ray inspection, and other engineering test or inspection methods.) (3.1)
Production Testing and Inspection (This includes methods of testing and inspection for setting up production standards, grading, gaging, maintaining quality, etc.) (3.2)
Maintenance Testing and Inspection (Included here are matters concerning standards and methods for controlling performance or service of equipment. Example—The problem of controlling long phone lines to give quality sound transmission would be included here.) (3.3)

ELECTRICITY and MAGNETISM (4)

Electrical Properties, Tests, Measurements, and Measuring Instruments (4.1)
Electrical Measuring Devices and Applications (4.2)
Magnetic Measurements (4.3)
Magnetic Properties, Materials, and their Applications (4.4)

ELECTRONICS and RADIO (5)

Radio Measurements (5.1)
Applications of Radio to Measurement and Control (5.2)
Photo-electric Measurements, Devices and Applications (including television) **(5.3)**
Electronic Measurements, Tubes, Devices, and their Applications (Under this heading are included thermionic tubes, grid-glow tubes, thyratrons, neon discharge tubes, cathode-ray tubes, etc.) **(5.4)**

ACOUSTICS and VIBRATIONS (6)

Sound, Vibration, Phenomena and Measurements (6.1)
Sound and Vibration Devices or Applications (6.2)

LIGHT, OPTICS, and RAYS (7)

Light—General Measurements and Optical Applications (7.1)
Color Analysis, Color Matching (7.2)
Photometry (7.3)
Polarimetry (7.4)
Spectrometry (7.5)
Photography (7.6)
Microscopy (7.7)
Electromagnetic Rays (This heading covers all electromagnetic rays other than visible light: infra-red, heat rays, ultra-violet, X-rays, alpha, beta, gamma, cathode, and cosmic rays.) **(7.8)**

CHEMISTRY (8)

Under this heading are chemical measurements, analysis, and their control applications.

ASTRONOMY, NAVIGATION, AVIATION (9)

Included in this section are, beside usual matters concerning astronomy, navigation and aviation, special matter on direction-control such as range finding, direction finding, radio beacons, etc.

GEODESY, GEOLOGY (10)

This section covers seismology, geophysical prospecting methods, etc.

INSTRUMENT DESIGN and CONSTRUCTION (11)

Matters concerning new instruments, their design, operation and manufacture, are included under this heading.

GENERAL and MISCELLANEOUS (12)

This section includes: First; general items of interest to all in the field of measurement and control. Example—"Possibilities of Vacuum Tubes for Application to Measurement and Control" is an article of universal interest in the fields of measurement and control. Second; miscellaneous items of general interest because not includable under any of the above classifications. Finally, items of general interest to all fields of measurement and control, such as historical material, biographical, etc.

General (of interest to all in measurement or control fields) **(12.1)**
Miscellaneous (12.2)
Historical and Biographical (12.3)
Bibliographical (12.4)
Economic (12.5)

CONTROL FUNCTIONING EQUIPMENT (13)

Literature on the equipment used by operators or automatic controllers to perform their control functions is covered under this heading. For example, the drum controller and associated switches, rheostats, relays, and motor starters by which an operator controls the motion of a crane are all pieces of "control functioning equipment."

Mechanical Control Functioning Equipment (13.1)
Electrical Control Functioning Equipment (13.2)
Includes drum controllers, relays, solenoids, etc.

MEASUREMENT TECHNOLOGY (1)

Measurement Practice (1.2)

On the Decimal Equation in Reading Scales. II. Effects of Line Width and Interval Size on the Decimal Equation with Symmetric Scales. (Über die Dezimalgleichung beim Ablesen von Skalen. II. Einflusse von Strichdicke und Intervallgrösse der Skalen auf die Dezimalgleichung bei symmetrischen Skalen.) H. Bäckström, *Zeitschrift für Instrumentenkunde*, Vol. 52, March 1932, pages 105-123.

Method developed in first report (see *Zeitschrift für Instrumentenkunde*, Vol. 50, 1930, pages 568-571) on the investigation of the decimal equation has been extended to determine effects of line width and interval on the decimal equation with symmetrical scales. The problem is dealt with under the following heads: (1) Effect of line width of the scale on mean error in decimal estimation; (2) Effect of line width on the subjective subdivision of the interval; (3) Remarks on the procedure in decimal estimation; (4) Interval and relative accuracy of estimation; (5) Interval and absolute accuracy of estimation; (6) Critical review of literature on relation between accuracy of estimation and interval. GN (1.2)

On the Decimal Equation in Reading Scales. (Über die Dezimalgleichung beim Ablesen von Skalen.) H. Bäckström, *Zeitschrift für Instrumentenkunde*, Vol. 52, June 1932, pages 260-274.

Concludes previous report of author (*Zeitschrift für Instrumentenkunde*, March 1932, pages 105-123.) Results: (1) Average error of a series of decimal estimation changes with scale line width. A line width of 0.1 scale division seems best. Error of estimation rapidly increases with coarser lines. (2) Relative error of estimation (in scale divisions) depends on the size of the division. The error asymptotically approaches a minimum for very large divisions. Even at divisions of 1.5 mm. the error does not deviate much from this minimum. For smaller divisions the error rapidly increases with decreasing size of division. Therefore, in reading scales with small divisions magnifying glasses should be used to increase the size of the division to at least 1.5 mm. (3) Absolute error of estimation (in mm.) decreases with increasing subdivisions of the scale. For measurements of highest accuracy the scale should be finely subdivided. Absolute size of error of estimation changes linearly with the size of the division. (4) There exists a lower limit for the error of estimation. With 2 groups of persons errors of estimation of 0.011 and 0.008 mm. were found, which is in agreement with value of 0.01 mm. found in the literature. (5) The linear equation for relation between accuracy of estimation and size of division seems superior to other relations. Selected bibliography.
GN (1.2)

Calculation (1.3)

The Calculation of Areas from Coördinates with the Computing Machine. (Zur Flachenberechnung aus Koordinaten mit Hilfe der Rechenmaschine.) E. Ruehle, *Zeitschrift für Vermessungswesen*, Vol. 61, April 15, 1932, pages 250-252.

Describes method by which evaluation of triangles in a survey can be effected with a computing machine semi-automatically; result obtained without intermediary calculations and it does not matter whether the area has an even or odd number of corners. Ha (1.3)

The Brunsviga Calculating Machine "Doppel Nova" (Die Brunsviga Rechenmaschine "Doppel Nova.") P. Werkmeister. *Zeitschrift fuer Instrumentenkunde*, Vol. 51, Nov. 1931, pages 586-587.

Represents combination of two calculating machines. Apart from elementary addition and subtraction work, the new calculating machine is fitted for the simultaneous multiplication of two products. EF (1.3)

Pattern-Boards in Practical Arithmetic. (Rechenschablonen im praktischen Zahlenrechnen.) P. Terebesi. *Zeitschrift fuer Instrumentenkunde*, Vol. 51, Oct. 1931, pages 535-541.

Author describes various schemes for handling a large number of figures, cutting down errors, simplifying routine work in the fields of mathematics and preventing early fatigue in carrying out complicated arithmetical work. EF (1.3)

The Solution of a System of Linear Equations with the Aid of the Calculating Machine "Hamann Automat." (Die Auflösung eines Systems Linearer Gleichungen mit Hilfe der Rechenmaschine "Hamann-Automat.") P. Werkmeister. *Zeitschrift fuer Instrumentenkunde*, Vol. 51, Sept. 1931, pages 490-491.

New application for calculator "Hamann Automat" built by the Deutsche Telefonwerke & Kabel-industrie A.G. EF (1.3)

Can the Bursting Pressure of any Testing Area be Approximately Calculated if the Bursting Pressure of Another Testing Area is Known? (Lassen sich bei Kenntnis des Berstdruckes für eine Prüffläche die Berstdrucke für andere Prüfflächen durch Rechnung annähernd bestimmen?) G. Bierett & B. Schulze. *Der Papier-Fabrikant*, Vol. 29, April 12, 1931, pages 231-234.

Yes, *i.e.* by the following formula: $\frac{pm}{pn} = \frac{x/fn}{\sqrt{fm}}$, wherein $x = 1.7$, p = pressure, f = area. The formula is, however, not applicable to papers with a low bursting resistance, say 0.6 kg./cm.^{2} at 10 cm.^{2} testing area due to the great experimental errors. EF (1.3)

The Determination of the Starting Voltage of Spherical Spark Gaps. (Zur Bestimmung der Anfangspannung von Kugelfunkenstrecken.) A. M. Zalessky. *Elektrotechnik und Maschinenbau*, Vol. 50, March 6, 1932, pages 149-151.

A formula is developed for the starting voltage of a spark gap which modifies the formula of Peek so that even variation of the breakdown field strength with the separation of the spheres is taken care of. Calculation and tests give fairly close agreement; a nomograph is developed for convenience. Ha (1.3)

Length, Angle, and Area, Including Surveying (2.01)

Repetition-Theodolite with Reading through Fennel Fine-Measuring Microscopes. (Repetitionstheodolite mit Ablesung durch Fennel- Feinmessmikroskope.) A. FENNEL. *Zeitschrift für Vermessungswesen,* Vol. 61, April 1, 1932, pages 209-214.

A new microscope has a plane-parallel glass plate inserted between the objective lens and the plane of the image; by tilting the glass plate the image of the circular division is shifted against a fixed mark in the field of vision. The magnitude of the tilting can be read on an auxiliary division and gives a much greater accuracy than is possible with the usual estimation; it acts like a vernier. The arrangement is described and illustrated; 14 references are cited. Ha (2.01)

The Use of the Protractor for the Determination of the Angle of Inclination of Expanded Tapes. (Die Verwendung des Gradbogens zur Bestimmung der Neigüngswinkel gespannter Schnüre.) FR. PERZ. *Berg-und Huttenmännisches Jahrbuch.* Vol. 80, March 15, 1932, pages 23-35.

The accuracy which can be obtained by the use of the protractor is treated analytically. A connection is shown between the properties of the tape or rope used and the accuracy of the measurement. The catenary is not realized in practice as the elasticity and changing weight alter this curve. These conditions are treated theoretically and corrections developed for the physical properties of the tape. This leads to the determination of the proper place of suspension of the protractor on the tape. Ha (2.01)

New Methods of Fibre Measurement. (Neue Wege der Fasermessung.) H. MEYER. *Melliand Textilberichte,* Vol. 12, Nov. 1931, pages 683-686; Dec. 1931, pages 743-745.

The standardization tendencies at the International Wool Conference, Liège, 1930, are anticipated and the recent suggestions of Fraser-Roberts (determination of fineness of wool), Barker & King (combined micro-weighing and projection method), New & Alty (weighing method determining the weight of the elementary fibre), Krauter (weighing method) are given and attention is called to the "Fibre Meter of the NWK" (Nordwolle Konzern) covered by the German patent 510,298. The instrument is designed for the measurement of the average fibre fineness as well as for the fibre length by optical (microscope) and weighing (torsion balance) devices. The features of the instruments are detailed, the performance of the different measurements and 6 formulae for the evaluation of the data are discussed at length. Limit of error amounts to only ± 2%. 4 figs. EF (2.01)

Fine Measuring Method for Radius of Curvature of Edges, Wires, etc. (Feinmessverfahren fur Krummungshalbmesser von Schneiden Drahten u. dgl.) *Zeitschrift Verein Deutscher Ingenieure,* Vol. 76, Feb. 6, 1932, page 134.

By placing a little test piece on the edge to be tested and slowly turning the latter, the change of equilibrium in the two positions can be used for the determination of the radius of curvature. Ha (2.01)

Precision Measurement of Small Cylindrical Pieces. (Präzisionsmessung kleiner zylindrischer Stücke.) *Schweizerische Technische Zeitschrift,* Vol. 29, April 7, 1932, pages 220-221.

Describes apparatus, built by Micromécanique S.A., Neuenburg, Switzerland, which reads accurately 0.001 mm. GN (2.01)

Application of Invar Wire for Surveying Problems in Finland. (Grundlinienmessung mit Invardraehten in Finnland.) P. WERKMEISTER. *Zeitschrift fuer Instrumentenkunde,* Vol. 51, April 1931, pages 213-214.

Reviews recent publications of the Finnish Geodetic Institute. EF (2.01)

A New Self-Reducing Theodolite. (Ein neuer selbstreduzierender Theodolit der Firma Georg Butenschoen in Bahrenfeld bei Hamburg.) P. SCHLICHTING. *Zeitschrift fuer Instrumentenkunde,* Vol. 51, Nov. 1931, pages 579-582.

Different principles embodied in the commercial self-reducing theodolites. Inadequacies inherent in instruments based on Hammer's design and salient features of the Butenschoen instrument aiming to overcome these deficiencies. EF (2.01)

An Improved Balloon Theodolite. (Ein verbesserter Ballon-Theodolit.) KOEGLER. *Zeitschrift fuer Instrumentenkunde,* Vol. 51, Jan. 1931, pages 37-38.

Refers to an instrument brought out by the E. Sprenger Co., and discusses a new crossed-thread illumination (Osram Lamp of 4 volts, 4 watt) for balloons ascending during the night time to altitudes of more than 10,000 m. (max. reached as yet 12,700 m.) EF (2.01)

Polar Coördinatograph of the Haag-Streit Company, Bern. (Polarkoordinatorgraph der Firma Haag-Streit, Bern.) P. WERKMEISTER. *Zeitschrift fuer Instrumentenkunde,* Vol. 51, Sept. 1931, pages 494-495.

Detailed description of new instrument. EF (2.01)

A New Piston-Ring Tape Measure. (Ein neues Kolbenring Bandmass.) O. SCHWENK. *Deutsche Motorzeitschrift,* Vol. 8, Aug. 1931, page 304.

The inadequate measurement of piston ring diameters with the caliper is pointed out. The "Circometer," mainly consisting of a flexible steel tape, is so calibrated as to make direct readings of the diameter in mm. and in. on a vernier, and can be used for any kind of cylindrical bodies. EF (2.01)

Contributions to the Methods of Fibre Measurement. (Beitrag zur Methode der Faservessung.) B. SCHULZE. *Zellstoff & Papier,* Vol. 11, Jan. 1931, pages 24-26. *Der Papier-Fabrikant,* Vol. 29, Jan. 4, 1931, pages 4-5.

Describes method for direct determination of fibre dimensions by measuring out a screen projection, and gives instructions in regard to sampling. EF (2.01)

Wall Thickness Determination on Hollow Shafts by Optical Means with the Object of Detecting Shifting of Center. (Wandstnerkenbestimmung von Hohlwellen auf optischem Wege zur Ermittlung von Bohrungsverlagerungen.) *Werft, Reederei und Hafen,* Vol. 12, Oct. 1, 1931, page 346.

Optical devices for checking accurate centering of long hollow shafts after installation. Wall thickness differences of 0.005 mm. are revealed. 4 figs. EF (2.01)

Time, Speed, and Acceleration (2.02)

The Application of Radio to Time Measurements. (Die Radiotechnik im Dienste der Zeitmessung.) J. BALTZER. *Zeitschrift fuer Fernmeldetechnik, Werkund Geraetebau,* Vol. 11, April 30, 1930, pages 58-62.

The subject is treated under the following headings: Historical development of time signals; the Nauen "Onogo" signal and the technique of its release for broadcasting; the reception of the "Onogo" time signal; coincidence signals; short waves for the avoidance of electrical contacts for most precise time recording and measurements; wireless regulation and adjustment of clocks. EF (2.02)

A Frequency Clock. (Eine Frequenzuhr.) E. THIELMANN. *Zeitschrift für Technische Physik,* Vol. 13, No. 4, 1932, pages 204-205.

A small motor generator produces oscillations reproduced by loudspeakers. Combination sounds are developed which are indicated on the scale of the instrument. The method of measurement is explained. Ha (2.02)

Progress in Time Measuring Technique. (Forschrifte der Zeitmesstechnik.) E. TREBESIUS. *Allgemeine Vermessungsnachrichten,* Vol. 44, Mar. 23, 1932, pages 177-179.

While the standard meter and standard kilogram are practically absolute measures, such standard does not exist yet for the time-intervals based on the solar day and stellar day are by no means absolutely uniform. The changes and their causes are explained and a few constructions of clocks described which are intended to give an absolutely uniform time; the "Synchronome" of Shortt in Greenwich, the balance pendulum of Schuler in Goettingen and the crystal clock of Marrison show changes of only 1/100 to 1/200 of a second per day. The last named operates without pendulum, using an oscillating crystal whose piezo-electric current is used for driving the clockwork. Ha (2.02)

Time Stamps and Time Stamp Installation. (Zeitstempel und Zeitstempelanlagen.) BRUNO MARTIN. *Ziemcus-Zeitschrift,* Vol. 12, March 1932, pages 107-112.

Describes the individual time stamp and the installation for operation of a number of stamps from a central time clock. Ha (2.02)

A Precision Clock with an Accuracy of 1/500 of a Second. (Eine Uhr, die bis auf 1/500 Sekunde genau geht. Die Schulersche Praezisionsuhr und die Vorhersage von Erdbegen.) L. J. BRAND. *Unschau,* Vol. 35, Jan. 24, 1931, pages 69-70.

The Schuler precision clock which takes into account the fluctuating length of a day is fully described. EF (2.02)

Investigation of the Various International Time Signals. (Eine Untersuchung der Verschiedenen internationalen Zeitzeichen.) P. LEJAY. *Zeitschrift fuer Instrumentenkunde,* Vol. 51, July 1931, page 380.

Briefly reports investigation of time signals flashed from Annapolis, Eiffel Tower, Greenwich, Nauen and Saigon. Signals were recorded by a photographic chronograph and the errors and irregularities of the various stations were determined. EF (2.02)

A Non-Sparking Synchronizer for Acceleration and Retardation (Ein funkenfreier Synchronisierapparat fuer Nachund Voreilen.) H. BOCK. *Zeitschrift fuer Instrumentenkunde,* Vol. 51, April 1931, pages 197-204.

Describes means for accelerating or retarding the pendulum of a clock electromagnetically operated. Lays stress on absolute absence of sparks at the contacts. Analyzes the synchronizing effect, the magnitude of the force transmitted by the electromagnetic coupling and the course of the synchronizing currents. EF (2.02)

On a New Method of Measuring Explosion Velocity. (Eine neue Art der Messung der Detonationsgeschwindigkeit.) W. FRIEDRICH. *Zeitschrift fuer das gesamte Schiess & Sprengstoffwesen,* Vol. 26, July 1931, pages 221-222.

Critically discusses deficiencies of following customary testing methods: (1) spark time measurement according to Siemens, (2) Le Boulange chronograph, (3) condenser time measurement, (4) optical time meter, (5) indirect determination according to Dautriche. Describes author's new direct measurement: Two fuses, a short one and another 8 meters longer, are connected with a percussion cap; free ends are placed into tapered holes in a steel block near which a drum rotates rapidly. After the explosion, two marks are found on the drum, their distance apart being a measure of explosion speed. EF (2.02)

The Necessity for a Standard Time Measure and the Present Status of My Endeavors to Establish a Time Normal. (Die Notwendigkeit eines Normalmasses der Zeit und meine bisherigen Erfolge beim Schaffen einer Zeitnormale.) MAX SCHULER. *Zeitschrift für technische Physik,* Vol. 4, Dec. 1931, pages 678-684.

The necessity for a normal measure of time with an accuracy of better than 10^{-6} is pointed out and the novel clock with compensating pendulum developed in the Observatory of Goettingen is described. See also "The Importance of a Standard of Time," *Instruments,* Vol. 5, June 1932, page A 10. EF (2.02)

Testing of Conical Internal Threads. (Die Prüfung konischer Innengewinde.) A. WERNER, G. BOCHMANN & R. LEHMANN. *Zeitschrift für Instrumentenkunde,* Vol. 52, Jan. 1932, pages 14-19.

According to specifications of American Petroleum Institute, methods have been devised by Physikalisch-Technische Reichsanstalt for determining thread profile, pitch and conicity of tube threads from about 1″ to 24″. Instruments are described; results of practical tests are summarized. GN (2.02)

Distance Measurement with a Horizontally Acting Tangent Screw. (Beitrag zur Streckenmessung mit einer horizontal wirkenden Tangensschraube.) P. WERKMEISTER. *Zeitschrift für Instrumentenkunde,* Vol. 52, April 1932, pages 183-187.

In a former report of author (*Zeitschrift für Vermessungswesen,* Vol. 60, 1922, pages 320-333-353-363) which discussed experiences with the Zeiss theodolite for distance measurement, the application of a horizontally acting tangent screw to the measurement of large distances was stressed. Present paper presents results of further investigations, shows that the tangent screw can also be applied to the measurement of short distances, discusses accuracy obtained in measuring with tangent screws. 6 references. GN (2.02)

Weight, Density, and Specific Gravity (2.03)

The Conversion of the Mohr-Westphal Balance to Other Standard Temperature and Density Units. (Die Umstellung der Mohr-Westphalschen Waage auf andere Normaltemperaturen und Dichteeinheiten.) W. BLOCK. *Die Chemische Fabrik*, Vol. 4, Sept. 16, 1931, pages 374-376; Vol. 4, Sept. 23, 1930, page 383.

In order to use the standardized density unit, i.e., water at 4°C. during determinations of specific gravities with the Mohr Westphal Balance and in order directly to obtain data referring to 15° to 20°C. respectively, one can either slightly change the weight of the beam riders or the volume of the float. The author explains the simple conversions necessary and presents the numerical constants for making them. It is furthermore pointed out that in no event can the reading of the Mohr-Westphal Balance be taken without taking into account a correction. The conversion of the density unit of 15°C. to the density unit at 4°C. can be achieved without reconstruction of the balance itself but solely with the aid of a correction table. EF (2.03)

The Accuracy of Measurements with the Torsion-Balance. (Ueber die Genauigkeit der Messung mit der Drehwage.) R. SCHUMANN. *Zeitschrift fuer Instrumentenkunde*, Vol. 51, Aug. 1931, pages 426-430.

Critical discussion. EF (2.03)

The Belani Load Indicator. (Der Belani-Belastungsanzeiger.) *Montanistische Rundschau*, Vol. 25, April 1, 1932, pages 5-6.

A simple instrument is described which indicates excessive loads carried by the springs of box cars, automobiles and other vehicles. GN (2.03)

Weight Meter for Liquid Crude Oil Products. (Gewichtsmesser fuer fluessige Erdoelprodukte.) N. SARUCHANOFF. *Petroleum*, Vol. 24, June 10, 1931, pages 3-5.

The instrument, for which a patent is applied, mainly represents a manometer in which the pressure prevailing at the bottom of the oil storage tank is checked against the pressure of a small container filled with compressed air. The manometer reading is multiplied by the cross-section area of the tank and some instrument coefficients. The result gives the total weight of the content of the storage tank. EF (2.03)

Temperature and Specific Gravity Determinations of Liquids. (Bestimmung von Temperatur und spezifischen Gewichts von Fluessigkeiten.) M. MOELLER. *Petroleum*, Vol. 24, July 8, 1931, pages 10-13.

Discusses instruments distributed by the Ed. Sprenger Co. EF (2.03)

Pressure and Vacuum (2.04)

Special Mechanical Indicators. (Mechanische Spezial-Indikatoren.) H. D. BRASCH. *Archiv für Technisches Messen*, Vol. 1, March 30, 1932, section J 137-2, pages T24-25.

The indication of extremely rapid changes of pressures (explosion motors, firearms) require extremely small masses in order to record the transients without distortion. Three types of indicators are used for this purpose: Micro indicators, the diagrams of which have to be magnified; optical indicators, which have no inertia, but are mostly restricted to laboratory use; and point-by-point indicators, which record only a momentary state of conditions which run over the whole cycle to be indicated. These methods and instruments for them are described. Ha (2.04)

Manometer for Measuring Low Pressures of Readily Condensible Gases. (Uber ein Manometer zur Messung niedriger Drucke leichtkondensierbarer Gase.) T. G. PEARSON. *Zeitschrift fuer physikalische Chemie, Section A*, Vol. 156, Sept. 1931, pages 86-88.

A manometer is described which measures the pressure of easily condensing gases to an accuracy of 0.005 mm. EF (2.04)

Flow and Volume (2.05)

Flow Measurement and Control. M. F. BÉHAR. *Instruments*, Vol. 5, July 1932, pages 173-178.

This instalment begins the treatment of measuring elements of head meters. Discusses classifications on which engineering societies and meter manufacturers do not agree and proposes new classification on basis of whether or not a measuring element ("scientific" or "commercial") can be considered "primary" in the sense that it can be calibrated without reference to a Standard instrument. Description of commercially available indicators is begun. 10 figs. (2.05)

Nomograms for the Measurement of Gas and Vapor Quantities. (Nomogramme zur Mengenmessung von Gasen und Dampfen.) H. RICHTER. *Zeitschrift Verein Deutscher Ingenieure*, Vol. 76, March 26, 1932, pages 320-322.

Based on the equation for the flow of gases, G, in kg./hr., $G = 15950\,\alpha\,\gamma\,F_0\,\sqrt{\gamma_1\,(P_1 - P_0)}$, a monogram is developed which gives directly and with correction factor the result for air, saturated steam, hot steam, and other gases. A few examples illustrate the procedure. 6 references. Ha (2.05)

New Condensing Devices for Steam Gages. (Neue Kondensationsgefaesse fuer Dampfmesser.) M. SCHACK & H. LOHMANN. *Die Wärme*, Vol. 53, Dec. 13, 1930, pages 950-952.

Steam flow measurements with the Venturi meter, Bunsen Schilling measuring flange, etc., are accompanied by a partial condensation which affects the measurement. The writers explain at length and demonstrate in 7 illustrations the latest designs of condensing devices which overcome the difficulties associated with the steam condensation. EF (2.05)

The Bayer-Siemens Float-meter for Steam Measurements. (Der Bayer-Siemens Schwimmesser als Dampfmesser.) JAEKEL. *Die Wärme*, Vol. 54, Feb. 28, 1931, pages 171-172.

The combined efforts of the I. G. Farbenindustrie and the Siemens & Halske A.G. led to the development of a new float meter, the various features of which are detailed and shown in 5 illustrations. EF (2.05)

The Application of Oil Filming to a Wet Capacity Meter. S. R. PRESTON. *Gas Journal*, Vol. 197, Feb. 3, 1932, pages 259-261.

Abridgment of a paper presented before the Australian Gas Institute. Discussion of wet meters in general, their construction, registration and oil filming, also of accuracy of dry meter. MAB (2.05)

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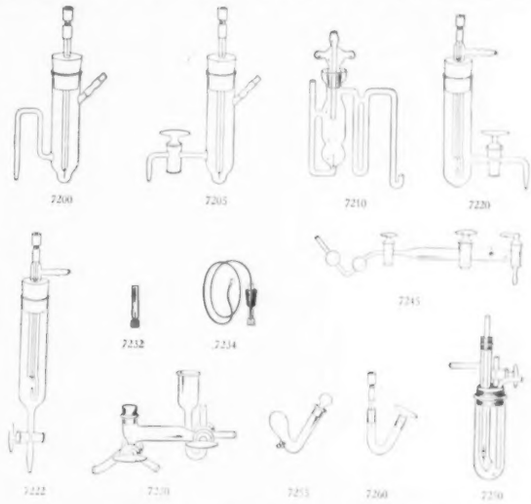

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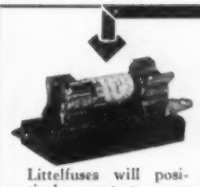

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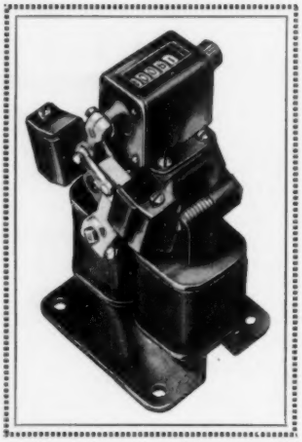

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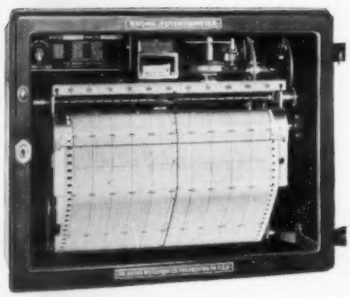

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